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The covers show details from Mesoamerican paintings on the Temple of the Jaguars at Chichen Itza with representations of a cloud serpent. They are believed to be the name glyphs of the Toltec rulers, Quetzalcoatl and Mixcoatl. See David Kelley's article beginning on page 39.

The Concept of a Meta-Font

Donald E. Knuth

A single drawing of a single letter reveals only a small part of what was in the designer's mind when that letter was drawn. But when precise instructions are given about how to make such a drawing, the intelligence of that letter can be captured in a way that permits us to obtain an infinite variety of related letters from the same specification. Instead of merely describing a single letter, such instructions explain how that letter would change its shape if other parameters of the design were changed. Thus an entire font of letters and other symbols can be specified so that each character adapts itself to varying conditions in an appropriate way. Initial experiments with a precise language for pen motions suggest strongly that the font designer of the future should not simply design isolated alphabets; the challenge will be to explain exactly how each design should adapt itself gracefully to a wide range of changes in the specification. This paper gives examples of a meta-font and explains the changeable parameters in its design.

Some of Aristotle's philosophical writings were called *Metaphysics*, because they came *after* his *Physics*, in the conventional arrangement of his works. By the twentieth century, most people had forgotten the original meaning of Greek prefixes, so that 'meta-' was assumed to add a transcendent character to whatever it qualified. We now have metapsychology (the study of how the mind relates to its containing body), metamathematics (the study of mathematical reasoning), and metalinguistics (the study of how language relates to culture); a metamathematician proves metatheorems (theorems about theorems), and a computer scientist often works with metalanguages (languages for describing languages). Newly coined words beginning with 'meta-' generally reflect our contemporary inclination to view things from outside, at

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a more abstract level, with what we feel is a more mature understanding.

In this sense a 'meta-font' is *a schematic description of how to draw a family of fonts*, not simply the drawings themselves. Such descriptions give more or less precise rules about how to produce drawings of letters, and the rules will ideally be expressed in terms of variable *parameters* so that a single description will actually specify many different drawings. The rules of a meta-font will thereby define many different individual fonts, depending on the settings of the parameters. For example, the American Type Founders specimen book of 1923 included the following members of its 'Caslon' family: plain, oldstyle, lightface, bold, heavy, condensed, lightface condensed, bold condensed, extra condensed, bold extended, shaded, and openface, not to mention American Caslon, New Caslon, Recut Caslon, and Caslon Adbold; each of these was available in about sixteen different point sizes, so the total number of Caslon roman fonts was about 270. There was an overall design concept loosely tying all these fonts together so that they were recognizably 'Caslon', although the changes in size and weight were accompanied by more or less subtle changes in the letter shapes. We can regard this overall design as a meta-font that specified how the letters would change in different circumstances—the meta-font governed the metamorphoses.

Of course, the actual design of all these Caslon varieties was not completely explicit; it was conveyed implicitly by means of a few drawings

that specified a few critical examples. A skilled workman could make the appropriate modifications for intermediate sizes and styles just as skilled animators do the 'in-betweening' for Walt Disney cartoons. It would be preferable, however, to have a completely explicit design, so that the designer's intentions would be unambiguously recorded; then we wouldn't have to resort to the vague notion of 'appropriate modifications'. Ideally, the designer's intentions should be so explicit that they can be carried out satisfactorily by somebody who doesn't understand letter shapes at all—even by a stupid, inanimate, electronic computer!

George Forsythe once wrote that 'The question "What can be automated?" is one of the most inspiring philosophical and practical questions of contemporary civilization.' We know from experience that we understand an idea much better after we have succeeded in teaching it to someone else; and the advent of computers has brought the realization that even more is true: The best way to understand something is to know it so well that you can teach it to a computer. Machines provide the ultimate test, since they do not tolerate 'hand waving' and they have no 'common sense' to fill the gaps and vagaries in what we do almost unconsciously. In fact, research in artificial intelligence has shown that computers can do virtually any task that is traditionally associated with 'thinking,' but they have great difficulty accomplishing what people and animals do 'without thinking.' The art of letter design will not be fully understood until it can be

explained to a computer; and the process of seeking such explanations will surely be instructive for all concerned. People often find that the knowledge gained while writing computer programs is far more valuable than the computer's eventual output.

In order to explain a font design to a machine, we need some sort of language or notation that describes the process of letter construction. Drawings themselves do not suffice, unless the design is so simple that all fonts of the family are related to each other by elementary transformations. Several notations for the precise description of letter shapes have been introduced in recent years, including one that the author developed during 1977–1979. The latter system, called METAFONT, differs from previous approaches in that it describes the motion of the center of a 'pen' or 'eraser' instead of describing the boundary of each character. As a result, the METAFONT language appears to facilitate the design of font families; for example, it took only about two weeks of work to create the crude but passable meta-font described in reference [5].

After another six months of development, during which literally thousands of refinements were made, the design of this prototype meta-font has reached its current state, which was used to typeset the present article. The name Computer Modern has been attached to the resulting group of fonts, a family that includes meta-fonts for both roman and italic styles in addition to the Greek and Cyrillic alphabets and an upper-case calligraphic script, together with an extensive set of mathematical

symbols. The basic idea underlying the design of this font family was to capture the spirit of the 'Monotype Modern Extended 8A' fonts used in the first printings of the author's books on computer programming, but to cast the design in the METAFONT idiom and to include a wide range of parametric variations.

So many variations are possible, in fact, that the author keeps finding new settings of the parameters that give surprisingly attractive effects not anticipated in the original design; the parameters that give the most readability and visual appeal may never be found, since there are infinitely many possibilities. On the other hand, it would be possible to parameterize many other things that cannot be varied in the present design; an almost endless series of interesting experiments can be performed, now that METAFONT is available.

Computer Modern Roman has 28 parameters that affect the shapes of its letters, plus three parameters that help control inter-letter spacing. There are also a few miscellaneous parameters whose sole function is to select alternate character and ligature shapes in different fonts. For example, one of the latter parameters is used to select between two styles for the letter 'g'; the reader may have already noticed that the g's in the present paragraph are different from those used elsewhere in this article. A few other typographic tricks like this will be played in what follows; large type has been used so that the effects will not be impossible to perceive.

The most interesting and important parameters of Computer Modern will be changed in the following paragraphs, one at a time, in order to show how much variability is possible. Of course it is easy to find settings of the parameters that don't give satisfactory results, since a single design cannot be expected to solve all conceivable problems; therefore our examples will attempt to illustrate the limiting cases where things break down as well as the in-between regions where usable fonts are to be found.

The first and most obvious group of parameters controls the vertical dimensions of letters: The x-height and the heights of ascenders and descenders can be independently specified. There are, in fact, two independent measurements for descenders, one to control the depths of the letters gjpqy and the other to control the depths of other symbols like commas and the tail of the letter Q. The height of upper-case letters is independent of the height of lower-case letters, and the height of the numerals 0 to 9 can also be varied at will. The most unusual parameter relating to vertical dimensions is called the e-height, namely the height of the bar in a lower-case e; in the current designs the e-height also affects several other lower-case letters:

the sack, the sack, the sack,
the sack, the sack!

Another fairly obvious group of parameters governs the horizontal dimensions of the characters: It is possible to obtain fonts that are

extremely extended or **extremely condensed without changing the heights or widths of the strokes.** One can also imitate a typewriter by extending or condensing the individual characters so that each one has the same width. Note that the length of serifs is proportional to the width, so that an i has much longer serifs than an m in the typewriter style.

Of course we get a much better imitation of a typewriter when the distinction between thick and thin strokes disappears. Such a font looks typewriter-like even when its letters do not all have the same width.

The letters of Computer Modern are all drawn by pens having an elliptical nib; for example, the thick strokes of the h's in this sentence were made by a pen that would look like ' ' if enlarged ten times. The ellipses have perfectly horizontal axes, not tipped as ' ', because the letters are intended to have vertical stress. Different pens are used to draw different parts of the letters.

Five parameters control the dimensions of these elliptical pens: One for the thin hairlines, another for thick stem lines that are straight, another for thick stem lines that are curved, another for the bulbs on letters like acf...y, and another that gives an aspect ratio between horizontal and vertical dimensions. The height of the hairline pen is used also as the height of the pens that draw the thick vertical stem lines. If the first four of these pen-width parameters are equal and if the aspect ratio is 1/1, the pens will be perfect circles.

An ellipse like '  ' has an aspect ratio of 1/3, while the aspect ratio of '  ' is 3/1. It is interesting to see what happens when sans-serif letters are drawn with pens of different aspect ratios:

A pen of aspect 1/3 generated these letters.
A pen of aspect 2/3 generated these letters.
A pen of aspect 1/1 generated these letters.
A pen of aspect 3/2 generated these letters.
A pen of aspect 3/1 generated these letters.

The aspect ratio can also be varied when the pens have different widths and serifs are present; in this case the aspect affects the darkness of letters like g and s that have thick horizontal strokes:

A pen of aspect 1/3 generated these letters.
A pen of aspect 2/3 generated these letters.
A pen of aspect 1/1 generated these letters.
A pen of aspect 3/2 generated these letters.
A pen of aspect 3/1 generated these letters.

(In the examples above, the widths of thick vertical stems for aspect ratios less than 1 are equal to the heights of thick horizontal stems for aspect ratios greater than 1.)

Special care is needed in the choices of the pen-width parameters. For example, undesirable blotches appear when the bulbs are too large for the stems; and the type has a disturbing inconsistency when the curved stems are substantially wider than the straight ones. **A font cannot get too bold without having portions of the letters run into each other.** Perhaps future meta-fonts will be

set up to compute desirable pen dimensions from a smaller set of independent parameters, since the proper widths depend in a subtle way on each other; at the moment, trial and error is necessary to get a compatible set of pens, but further research should shed some light on this dependence.

Only five pen-width parameters have been mentioned, for simplicity, but the actual situation is somewhat more complex. In the first place, the pens used for drawing upper-case letters are specified separately from those used to draw the lower-case ones, and numerals are drawn by mixing these two specifications. There is also a parametric 'fudge factor' that takes some weight off of letters like w and m, which otherwise would look too dark in some styles; true uniformity in line widths does not lead to uniform appearance, because our eyes play tricks on us.

Another slightly subtle parameter of the Computer Modern fonts is the so-called 'overshoot' by which curves and sharp corners descend below the baseline and above the mean line. For example, the letters in this sentence have no overshoot at all. And certain letters in this sentence overshoot their boundaries by thrice as much as they do in the following sentences. Experimentation is still necessary to find the amount of overshoot that makes the letters look most stable, and on low resolution printing equipment it is desirable to eliminate overshoot entirely; further study of this parameter, in combination with the others, would be quite interesting.

Serif details can be varied in several ways. For example, there are no 'sheared' serifs on the letters in this sentence. And the letters you are now reading have thrice as much shear as usual, just to make sure that the concept of shear is clear. Another serif-oriented concept is the amount of 'bracketing'; the serifs in this sentence have no brackets. But the brackets are exaggerated in this sentence, so the serifs appear darker. The difference can be understood most easily if we enlarge the letters:

no bracketing;

normal bracketing;

noticeable bracketing.

A curve that starts at the edge of the serif will be tangent to the stem at some distance above or below the serif; this vertical distance is the 'bracketing' parameter.

A third parameter affecting serifs is called the 'crispness': The example serifs above have been crisply squared off, using a special rectangular pen instead of an ellipse, but one can also specify

no crispness,

in which case only the elliptical pens are used. The typewriter-like font examples above are non-crisp.

The length of serifs is, of course, controllable too. The letters in this sentence have serifs that are 50% shorter than before. And in this sentence they are 50% longer than before—so long

that they sometimes touch where they shouldn't. To get sans-serif letters, one simply sets the serif length to zero (and makes appropriate changes in the inter-letter spacing). The sans-serif letters in Computer Modern Roman have 'soft' endpoints because they are drawn with elliptical pens; it would be possible to get crisp edges by extending the Computer Modern routines, but sans-serif fonts were not given high priority in this particular design.

A 'slant' parameter transforms the pen motion, as shown in this sentence, but the pen shape remains the same. The degree of slant can be negative as well as positive, if unusual effects are desired. *Too much slant leads, of course, to letters that are nearly unreadable.* Perhaps the most interesting use of the slant parameter occurs when Computer Modern Italic fonts are generated without any slant: Italic letters have a different style from roman, and we are so used to seeing such letters slanted forward that they appear to be slanting backward when they are actually upright or slanting slightly forward.

The final parameter we shall discuss is the most interesting one; it is called 'the square root of 2'. From a mathematical standpoint, there is of course only one square root of 2, but the Computer Modern meta-fonts treat $\sqrt{2}$ as a variable parameter that is used to compute the 45° points when a pen is drawing elliptical curves. As a result, a value that is smaller than the true one will change an ellipse to a super-ellipse and open up the bowls, while a higher value will have the opposite effect:

The 'square root of 2' in these letters is 1.100.
The 'square root of 2' in these letters is 1.300.
The 'square root of 2' in these letters is 1.414.
The 'square root of 2' in these letters is 1.500.
The 'square root of 2' in these letters is 1.700.

Several additional parameters can be varied in addition to those we have mentioned; for example, there is an amount by which sharp corners in letters like V and M are spread apart to avoid unnecessary fill-in, and some parameters such as the serif length are specified independently for upper-case and lower-case letters. But a complete description of Computer Modern Roman is beyond the scope of this paper.

We have been studying the parameters one at a time—what happens when they are all changing at once? The next page shows one of the interesting transformations that are possible. At the top we have a font with an old-fashioned feeling, essentially the same as the style of type used so far in the text of this paper, except for scale: The h-height is 8.4 points, the x-height is 4 points, the e-height is 2.3 points, and the descender depth is 3 points. Hairlines are 0.26 points wide, compared to 1.2-point straight stems and 1.34-point curved stems; the bulb diameter is 1.36 points and the aspect ratio is 1/1. One em in this style equals 12.6 points; serifs are .07777 of an em long, and they have 0.54 points of shear, 0.8 points of bracketing. The overshoot parameter is 0.3 points, and the 'square root of 2' has its mathematically correct value 1.414214.

Continuous variation of parameters can gradually convert a font with an old-fashioned flavor into a contemporary style. All of the letters in this example have the same h-height, but their em width increases as their x-height increases. This gives a perspective effect in which the words come out of the past to the present, as they approach the future.

The LORD is my shepherd;
I shall not want.
He maketh me to lie down
in green pastures:
he leadeth me
beside the still waters.
He restoreth my soul:
he leadeth me
in the paths of righteousness
for his name's sake.
Yea, though I walk through the valley
of the shadow of death,
I will fear no evil:
for thou art with me;
thy rod and thy staff
they comfort me.
Thou preparest a table before me
in the presence of mine enemies:
thou anointest my head with oil,
my cup runneth over.
Surely goodness and mercy
shall follow me
all the days of my life:
and I will dwell
in the house of the LORD
for ever.

The letters at the end of the example on the previous page have been transformed into an almost hypermodern font, which will be used for the remainder of this article. The h-height is still 8.4 points, but the x-height has grown to 6.4 points and the e-height to 3.2; the descender depth is now 4 points. Hairlines and stem lines are both exactly one point wide, and bulbs have a diameter slightly larger (1.1 points); the aspect ratio is 3/5. One em is now 21.6 points; the serif length is zero, and so are the shear and bracketing parameters. There are 0.1 points of overshoot, and the 'square root of 2' is 1.3.

Each of the 593 letters, spaces, and punctuation marks in the example belongs to a different font, obtained by going 1/592 of the way further toward the final parameter settings. Thus, although each letter appears to be in the same font as its neighbors, the cumulative

change is quite dramatic—it is something like the gradual changes in our own faces as we grow older, except that this typeface is getting younger.

Hundreds of typefaces have appeared in this article, yet all of them belong to the Computer Modern Roman and Italic meta-fonts. Each letter has been specified by a computer program written in the METAFONT language, and the computer can draw any desired variant of that letter when the parameter values have been supplied. It is important to remember that none of these conventions and parameters are built into METAFONT itself; METAFONT is a general-purpose language intended to facilitate the design of meta-fonts, and Computer Modern is but one approach to font design using such a language.

Let us take a brief look at the program for the letter h, since this will give some insight into the way a meta-font can

be designed. Each Computer Modern Roman h is drawn essentially as follows, if we paraphrase the METAFONT code into English:

This character will be 10 units wide, where there are 18 units per em; however, the width should be adjusted by the 'serif correction' after the character has been drawn, to account for long or short serifs.

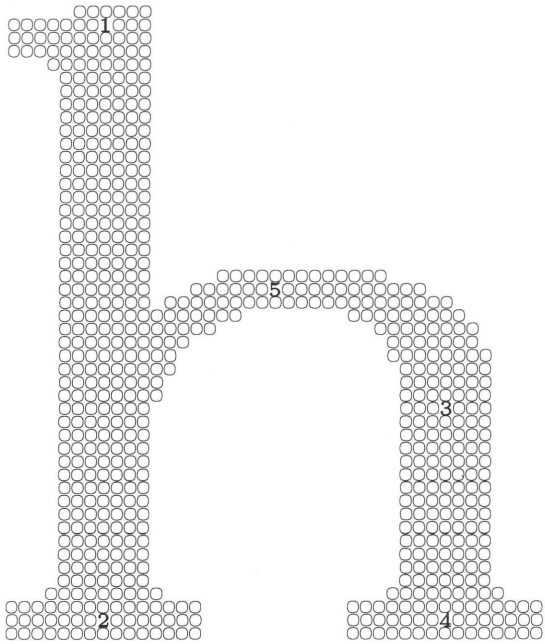
There are several key points in this letter, defined as follows: Take an elliptical pen whose height is equal to the hairline width times the aspect ratio, and whose width is equal to the straight stem width for lower-case letters. When this pen is centered at point 1, its center is approximately 2.5 units from the left edge of the character (rounded so that the center is in a good position with respect to the raster), and its top is at the h-height for lower-case letters. Point 2 is directly below point 1; the bottom of the pen will be exactly at the baseline when its center is at point 2. Points 3 and 4 both lie approximately 2.5 units from the right edge of the character; point 4 is directly to the right of point 2, while point 3 is 1/3 of the way from the e-height to the x-height.

Take the pen and draw a straight stem from point 1 to point 2, and another from point 3 to point 4. Put a sheared serif at the left of point 1, and attach serifs at both sides of points 2 and 4, using the serif sub-programs (which take proper account of the shear, bracketing, crispness, and serif-length parameters).

Finally, the shoulder of the h is drawn as follows: The stroke begins vertically at a point 1/8 of the way from the e-height to the x-height, using a hairline pen positioned flush right with the left stem line. This hairline pen traces a quarter-ellipse, ending at a point that is horizontally centered in the character and such that the pen's top is at the x-height plus half of the overshoot; let us call this point 5.

The shoulder is completed by drawing one quarter of a superellipse from point 5 to point 3 as the pen grows from the hairline width to the straight stem width; the midpoint of this arc is computed by using the geometric mean of the number 1.23114413 and the 'square root of 2' parameter, instead of $\sqrt{2}$, in the usual formulas for ellipses. (The strange constant 1.23114413 is $2^{3/10}$, chosen so that Piet Hein's famous superellipse will be obtained if the 'square root of 2' equals $\sqrt{2}$.)

Similar routines will yield the m and the n. Effects of the 'slant'



The program that is paraphrased in the text might prepare this character for a low-resolution printing device. Note the five key points numbered 1, 2, 3, 4, and 5; the center of the 'pen' travels through these points as it draws the letter.

parameter are not mentioned in this description, since slanting is done by a different part of the computer program, at the time the actual drawing is being produced.

The idea of a meta-font should now be clear. But what good is it? The ability to manipulate lots of parameters may be interesting and fun, but does anybody really need a $6\frac{1}{7}$-point font that is one fourth of the way between Baskerville and Helvetica?

We might consider also an analogy with music: Musical notation was developed centuries before we had a notation for drawing; during all this time there has been no widely perceived need for meta-symphonies, so why should we desire meta-fonts?

Well, these are legitimate questions that surely deserve to be answered; let's think about the musical analogy first. Mankind's long experience with musical notation shows clearly that the mere existence of a precise language does not by itself call for the introduction of parameters into that notation. Indeed, parameters have not crept into serious music, even in primitive ways, until very recently, except in a few almost-forgotten pieces like Mozart's meta-waltz [11]. It would surely be interesting and instructive to write meta-music that would produce variable degrees of suspense, excitement, pathos, sturm und drang in the

listener, depending on the setting of certain parameters; but there would be little apparent use for such music except in the sound track of motion pictures.

All analogies break down, of course, and font design is different from musical composition because alphabets are not symphonies; an alphabet is a 'medium' while a symphony is a 'message'.. We get a much better analogy between fonts and music when we consider background music rather than symphonies, since fonts serve as the background for an author's printed ideas. Many people resent background music because they feel that music should either be the main focus of a person's attention or it should be absent entirely, while it is generally agreed that the reader of a book should not be conscious of the g's and the k's in that book. A font should be sublime in its appearance but subliminal in its effect.

The utility of parametric variations comes from mankind's need for variety. We don't all want to live in identical houses or drive identical cars. Background music becomes especially tedious when it comes from a limited score having only a few motifs; and five centuries of typographic practice have witnessed a continual craving for new alphabets and for large families of related alphabets. Thus, although any one particular setting of a meta-font's parameters may seem to be somewhat silly and unnecessary, the ability to choose arbitrary parameter settings fills a real need. Book designers and the designers of advertising copy will have greater freedom than ever before when they have several meta-fonts to work with. Personalized fonts and one-time-only fonts will also be easy for anyone to obtain.

Another reason why meta-fonts and meta-music were not

highly developed long ago is the fact that computers did not exist until recently. People find it difficult and dull to carry out calculations with a multiplicity of parameters, while today's machines do such tasks with ease.

Perhaps the most important practical result of parametric variations is the ability to make adjustments for each point size; the contemporary tendency to obtain 7-point fonts by 70% reduction of 10-point fonts has led to a lamentable degradation of quality. Another advantage is that a meta-font can adapt its curves so that they are properly 'rounded' for the digital typesetting machines that are based on discrete rasters. This leads to a significant reduction in the need for manual editing of the raster patterns.

It is, of course, quite a challenge to design a meta-font instead of a single font. A designer wants to remain in control, yet the great variety

of possible parameter settings means that the meta-font is able to generate infinitely many alphabets, most of which will never be seen by human eyes; only a few of the possibilities can really be looked at, much less fine-tuned, before the specification of the meta-font has been completed. On the other hand, the designer of a meta-font has compensating advantages, because it is often convenient to be able to postpone making decisions about many aspects of a design and to leave them as parameters, instead of 'freezing' their specifications in the initial stages. Such things as the amount of overshoot, the width of hairlines, the length of serifs, and so on, need not be decided once and for all; it is easy to ask the computer to make experiments by which the designer will be able to choose the best settings of these subtle quantities after viewing actual typeset material. Experiments of

this kind would be unthinkable if each character had to be drawn individually—i.e., if each character were simply in a font rather than a meta-font.

In the long run the scientific aspects of meta-fonts should prove to be the most important. The ability to adjust continuous parameters makes it possible to carry out controlled experiments about how such variations affect readability or visual appeal. And even more significant will be the knowledge that will be explicitly embedded in the descriptions of meta-fonts. For example, the author learned a great deal about font design while refining the Computer Modern alphabets, and this information is now accessible to anybody who reads the **METAFONT** code. It is tantalizing to think how much further the art of font design will be advanced when professionals who really know the subject begin to create meta-fonts in an explicit language like **METAFONT**.

Annotated Bibliography

The nine-point type used to set this bibliography reflects the parameter settings for Computer Modern Roman that were used in its original design, based on the 'Monotype Modern 8' font; the more extreme settings used to typeset the text of the paper were chosen long after the design itself was complete, in order to illustrate the meta-font concept.

[1] P. J. M. Coueignoux, *Generation of roman printed fonts*, Ph.D. thesis, Dept. of Electrical Engineering, M.I.T., June 1975. This thesis represents the first use of sophisticated mathematical curves to describe letter shapes to a computer. Coueignoux and his students are presently continuing this research at the École Nationale Supérieure des Mines de Saint-Etienne, France.

[2] Adrian Frutiger, *Type Sign Symbol* (Zürich: ABC Verlag, 1980); see especially pages 15–21, which describe 'Why Univers was designed and how it developed.' Univers was the first true meta-font, in the sense that a wide variety of different sizes and weights played a central rôle in its design from the very beginning. 'The decisive factor for the many new design possibilities provided by Univers was that it became possible, for the first time, to work with a set of typefaces as a complete system.' Page 59 of this fascinating book shows a meta-letter n, called the 'proportional schema of a typeface family,' graphically depicting the desirable stroke variations as the font gets bolder.

[3] Peter Karow et al., 'IKARUS: computer controlled drafting, cutting and scanning of characters and signs. Automatic production of fonts for photo-, CRT and lasercomp machines. Summary.' (September 1979.) This booklet is available from URW Unternehmensberatung, Karow Rubow Weber GMBH, Harksheider Straße 102, 2000 Hamburg 65, Germany. The IKARUS system is now widely used to capture the shapes of letters in mathematical form, based on original artwork [cf. *Baseline* **3** (1981), 6–11]. The computer programs will also interpolate between different weights, although the number of independent parameters is quite limited; this feature was used successfully by Matthew Carter to develop several weights of his new Galliard type, including Ultra Roman [cf. Charles Bigelow, 'On type: Galliard,' *Fine Print* **5** (1979), 27–30].

[4] David Kindersley and Neil Wiseman, 'Computer-aided letter design,' *Printing World* (October 31, 1979), 12, 13, 17. Discusses the ELF system at Cambridge University, which features a novel method of optical spacing between letters.

[5] Donald E. Knuth, 'Mathematical typography,' *Bulletin of the American Mathematical Society* (new series) **1** (March 1979), 337–372; reprinted with corrections as part 1 of *TEX and METAFONT: New Directions in Typesetting* (Providence, R.I.: American Mathematical Society, and Bedford, Mass.: Digital Press, 1979). A paper written shortly after the author began his research on font generation; it explains the initial motivations for this work and shows an experimental roman meta-font.

[6] Donald E. Knuth, 'The letter S,' *The Mathematical Intelligencer* **2** (1980), 114–122. Discussion of the letter that is most difficult to incorporate into a parameterized meta-font.

[7] Donald E. Knuth, *Seminumerical Algorithms*, Volume 2 of *The Art of Computer Programming* (Reading, Mass.: Addison-Wesley, 1981). This book was the first large work to be typeset entirely with the Computer Modern meta-fonts; indeed, Computer Modern was developed expressly for the books in this series. The design of Computer Modern had still not been fully completed at the time of

printing; for example, the x-height settings were slightly higher than they are now, and certain characters like '2' have been revised. However, the alphabets in the present paper were obtained from those in *Seminumerical Algorithms* by making only a few dozen refinements. Such revisions and afterthoughts are probably inevitable, especially when the computer representation of a meta-font makes changes so easy; it is very hard to stop and say 'there will be no more improvements made!'

[8] Donald E. Knuth, *The Computer Modern Family of Type Faces*, a book in preparation, will contain the complete METAFONT programs for the Computer Modern Roman and Italic meta-fonts. A preliminary version of this book was published as Stanford Computer Science report STAN-CS-80-780 (January 1980), in order to illustrate the state of the work at that time, but hundreds of important refinements have been incorporated since those early days.

[9] J. R. Manning, 'Computer-aided footwear design: A method of constructing smooth curves,' Research report 251, Shoe and Allied Trades Research Association (December 1972, revised February 1953); available from Satra House, Rockingham Road, Kettering, Northants NN16 9JH, England. The clothing industry has needs analogous to those of type designers; this paper discusses the generation of curves that pass through given key points, and it includes a 'meta-shoe' as an example.

[10] H. W. Mergler and P. M. Vargo, 'One approach to computer assisted letter design,' *Visible Language* [neé *The Journal of Typographic Research*] **2** (1968), 299–322. This paper describes the first computer system for parametric letter design; it included a meta-font for upper-case roman letters. The approach was limited and unsuccessful because it was entirely based on edge generation with a limited class of curves and because of the equipment limitations of the 1960s, but the authors had laudable goals.

[11] Wolfgang A. Mozart, *Musikalisches Würfelspiel*, Edition Schott 4474 (Mainz: B. Schott's Söhne, 1957); see also Köchelverzeichnis 516f Anh. C30.01. This unusual score presents a waltz that can be played in 759,499,667,966,482 different ways, since there are eleven possibilities for most of the individual bars; the harmonic principles have been analyzed by Hermann Scherchen in *Gravesaner Blätter* **4** (May 1956), 3–14. Mozart also devised a meta-contredanse, and the British Museum reportedly owns a meta-score by Haydn. A noteworthy 20th-century example of meta-music can be found in *The Schillinger System of Musical Composition* by Joseph Schillinger (two volumes), New York: Carl Fischer, 1946.

[12] Edward Rondthaler, 'From the rigid to the flexible,' *Penrose Annual* **53** (1959), xv, 1–9. An early description of the variability of type that is possible with photographic transformations alone.

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English Spelling and Phonemic Representation

Royal Skousen

There are at least three different ways that spelling can affect phonemic representation: (1) spelling pronunciation; (2) resolving the ambiguities due to phonemic overlap; and (3) influencing speakers' interpretations of general phonetic sequences. The first of these is well known and is only discussed briefly in this paper. The other two ways are more subtle in their effect since they can change speakers' phonemic representations without causing significant changes in pronunciation.

In this paper I will discuss the effects of spelling on English phonology. Within recent years, orthographic evidence, especially the naive spellings of young children, has been used to support certain phonemic representations (e.g., Read, 1971, 1975; and Stampe, 1979). This evidence clearly shows that children's phonemic perceptions are frequently different from those of adults — even when there is no difference in pronunciation. In this paper I will argue that the orthography is responsible for many of these differences – that is, as speakers learn to read, their phonemic representations are frequently altered to agree with orthographic representation. These orthographic effects have important consequences for phonological theory, since linguistic arguments are usually based on adult perceptions of phonemic representation – perceptions that have been influenced by the orthography.

1. The best-known effect that spelling can have on phonemic representation is SPELLING PRONUNCIATION.[1] Spelling pronunciations have their origin in spelling exceptions. A spelling exception can be eliminated in two different ways: either the spelling can be changed so that it agrees with the pronunciation; or, vice versa, the pronunciation can be changed so that it agrees with the spelling. This second case results in a spelling pronunciation. Consider, for instance, the word *often*. For most speakers of English, the *t* in this word is silent and has been for the last couple centuries. In Middle English the *t* was pronounced, but due to a regular sound change the *t* was lost, so that by

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the eighteenth century, *often* was consistently pronounced as [ȯfən][2] (Jespersen, 1970:225). This spelling exception could be removed by changing the spelling to OFEN – or the spelling could remain constant and the pronunciation change, thus producing the spelling pronunciation [ȯften].

Two important properties of spelling pronunciation should be recognized. The first is that spelling pronunciations tend to revive pronunciations which existed earlier in the language. This tendency is due to the conservative nature of English spelling. English spelling is, of course, based on earlier pronunciation. Historical change introduces irregularities in the sound-letter correspondences, and spelling pronunciation frequently acts to reverse historical change and re-create historical pronunciations. Thus the spelling pronunciation of *often* as [ȯftən] reflects an earlier pronunciation of this word.[3]

Nonetheless, spelling pronunciations do not always reflect earlier pronunciation in the language. For instance, there are numerous words in English that have been borrowed from French but whose spelling was later changed to reflect the original Latin form. The word *perfect* was originally borrowed into Middle English from French as *parfit*, but in the seventeenth century this word was frequently spelled *perfect* on the basis of the original Latin form *perfectus*. This etymological spelling ultimately resulted in the spelling pronunciation [pərfikt] (Jespersen, 1970:394; OED 2130). Occasionally, the etymological source for the spelling may be incorrect, as in the example *hermit*. The original Greek *erēmítēs* began with a vowel, but the word was mistakingly interpreted by medieval Latinists as having an initial *h*. Thus Latin *eremita* was replaced by *heremita* (OED 1295).

The second property of spelling pronunciations is that they are idiosyncratic – that is, spelling pronunciation does not necessarily affect all the examples having the same spelling irregularity. Thus the pronunciation of the *t* in *often* has been re-introduced by spelling pronunciation, but in the word *soften* the spelling pronunciation [sȯftən] has not occurred to any appreciable extent. This example also seems to discount the possible effect of morphological relatedness in explaining which words are affected by spelling pronunciation. The morphological evidence for the *t* in *soften* is strong because of the highly frequent word *soft*, whereas the *t* in *often* is only weakly supported by the morphologically related word *oft*, which is quite infrequent in modern English.[4]

What then causes adult speakers to think that [ṽC] should be interpreted as /VNC/ ? There is little morphological evidence – perhaps *can/can't* is the only significant example. Moreover, there is no careful pronunciation which denasalizes the vowel. I would therefore suggest that it is the standard spelling which causes speakers to change their initial interpretation of the nasal vowel. This change is so pervasive that linguists automatically assume that [ṽC] is /VNC/. As a result, the child's spelling of *can't* as CAT is so surprising and, it would seem, unmotivated.

A second example of the influence of spelling on general phonemic perception deals with the syllable-initial consonant clusters *tr* and *dr*. Read found (1975:98) that a sizeable minority of children (about 30%) interpret these consonant clusters as /chr/ and /jr/ rather than /tr/ and /dr/, with the result that they spell *tr* as CHR and *dr* as JR: ASCHRAY *ashtray*, CHRIBLS *troubles*, CHRIE *try*, CWNCHRE *country*, CHRAC *truck*, and JRAGIN *dragon*. I have even observed in my beginning linguistics courses that there is an occasional student (though not ever as many as 30% of the class) who will transcribe syllable-initial *tr* and *dr* clusters as [chr] and [jr]. Again, we may ask what causes most mature speakers to think these consonant clusters begin with alveolar stops rather than palatal affricates. I know of no morphological evidence at all that would cause such a re-interpretation. A slight phonetic difference between /tr/ and /chr/ (or between /dr/ and /jr/) can be produced, but there is no need to distinguish between these two pronunciations since there are no /tr/-/chr/ (or /dr/-/jr/) contrasts in English. Once more, I would suggest that orthography is the source of the nearly unanimous adult interpretation of these consonant clusters as /tr/ and /dr/.

My final example deals with what we as adults perceive as possible initial consonant clusters in English. Chomsky, for instance, has frequently claimed that there are no initial consonant clusters like /ft/ and /bn/ in English (e.g., 1964:30-31), and that in a descriptively adequate grammar of English there should be general restrictions against such clusters. This is undoubtedly true for adult speakers of English whose interpretation of phonetic sequences has been influenced by the orthography. But in the naive spellings of children we find many examples of misspellings that would suggest that children often perceive initial consonant clusters differently than adults. In the standard orthography, certain clusters (such as /tm/ and /bn/) are always interpreted with an intervening schwa vowel, yet sometimes children apparently interpret these sequences as bona fide consonant clusters. Read (1975:61) provides an example of the /tm/cluster: TMORO *tomorrow;* and Gates (1937) records TMATO for *tomato*. I have observed a *bn* cluster: BNANA *banana*.

Other consonant clusters, such as /bl/, /gr/, and /pr/, can be spelled (depending on the word) with either a consonant cluster or with an intervening schwa (cf. *please* versus *police*), yet children frequently mix these up. Gates (1937) records these common misspellings: BLOON *balloon*, BLONG *belong*, BLOW *below*, GRAGE *garage*, PRADE *parade*. And Read (1975:69) provides an example of where the schwa has been incorrectly inserted: POLES *please*. Sometimes a vowel symbol may be inserted in a consonant cluster (such as /sw/) which is almost always spelled as a consonant cluster in the standard orthography: SOWEMEG *swimming* (Read 1975:36). It is the orthography then that almost always determines which word begins with a consonant cluster or a sequence of two consonants separated by a schwa, so that ultimately spelling affects our perception of the possible consonant clusters of English.

In conclusion, we see that English spelling has a significant effect on phonemic perception. In certain cases spelling helps to clear up the ambiguities of phonemic overlap and in other cases it affects the interpretation of general phonetic sequences. Spelling also serves as an important stabilizing factor in the language, since it influences careful pronunciation and helps the speaker to preserve certain sound distinctions psychologically. These effects also have important consequences for phonological theory, since many linguistic arguments are based on adult perceptions of phonemic representation. Spelling plays such an important role in restructuring the phonemic representations of speakers that any discussion of the acquisition of phonology should take into account the effects of spelling.[6]

1. For an excellent survey of spelling pronunciation, cf. Levitt 1978.
2. The pronunciation symbols used in this paper are based on those in *Webster's Third International Dictionary* (Merriam-Webster, Springfield, Massachusetts, 1963).
3. For a more extensive discussion of this effect of spelling pronunciation, cf. Kerek 1976.
4. Cf. the number of occurrences per million words of text for these words (Kučera and Francis 1967); *often* 367, *oft* 2, *soften* 20, *soft* 113.
5. Ehri and Wilce (1980) have recently provided some interesting experimental evidence that children's spellings of words like *interesting, general, family,* and *different* are dependent upon children's spelling knowledge: "Children were more apt to include extra syllables in their segmentations if they were familiar with the spellings of the words. If they did not know the spellings, then they were not likely to regard the syllables as present in the spoken forms" (p. 8).
6. This paper was first presented at Brigham Young University in June 1978. A shorter version was also read at the December 1979 meeting of the Linguistic Society of America in Los Angeles.

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Costume and Name in Mesoamerica

David H. Kelley

It was the practice in pre-Columbian Mesoamerica to wear costume elements, especially head-dresses, which gave the name of the individual wearing the particular costume. However, headdresses were also worn for other purposes, and it is often difficult to determine whether a costume element marked a name or some other characteristic of an individual. Nonetheless, the custom does sometimes enable us to recognize individuals in varied contexts.

In ancient Mesoamerica (from southern Mexico to northern Honduras), individuals were often identified by the incorporation in their costumes of various kinds of appellative glyphs. The principal classes of appellative glyphs that seem to be involved are personal names, including calendar names, family names, and personal or dynastic titles. Although it is often possible to recognize a particular individual by characteristics of his clothing, it is sometimes impossible to tell which class of appellative glyphs is being incorporated in the dress. Hence, although the emphasis in this paper is on the incorporation of personal names in dress, some examples may be doubtful.

A minor question which cannot yet be answered with certainty is whether representations in the codices and on the monuments should be understood as representing actual costumes worn (as seems likely) or whether they should be understood as merely graphic devices.

The most ample Mesoamerican source showing this practice is the *Bodleian* codex, written in the Mixtec area, probably after 1500 but before the arrival of the Spaniards. This codex often shows individuals wearing costumes on one page and gives genealogical cross-references to them on other pages. Often a costume of one page is found as a separate name glyph on another.

A few examples will suffice and will also illustrate some problems and difficulties of interpretation. The famous Eight Deer, ruler of Tilantongo, is often shown wearing a jaguar costume. When his name appears separately, it is simply written as a jaguar claw; we cannot be certain whether the jaguar costume is a marker of this or not. By a wife from Tula, he left descendants associated with Tula, including, according to the interpretation of Caso (1960), a granddaughter named One

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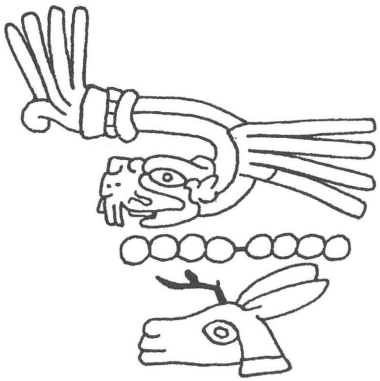
Flower who married another Eight Deer, of Tula. The latter Eight Deer is represented wearing a headdress composed of a serpent head and feathers (Figure 1a). As a separate name, this appears as a serpent with wing and tail feathers (Figure 1b) — in short, a Quetzalcoatl. It is virtually identical to the headdress of the human figure seated with the giant Feathered Serpent on the famed pyramid of Xochicalco (Toscano, 1970). It should be emphasized that this Eight Deer's costume, which apparently represents the name Quetzalcoatl, is very different from the costume of the god Quetzalcoatl, where the characteristics seem rather to be attributes of the god.

Caso thought that two of the children of Eight Deer of Tilantongo, Ten Earthquake Flaming Grey Eagle and his sister-wife, Two Twisted, had two daughters, Thirteen Rain (F), who married Seven Flint Mixcoatl, and One Flower (F), who married Eight Deer Quetzalcoatl. However, the *Bodleian* could better be interpreted as indicating that One Flower was a daughter of Seven Flint Mixcoatl (Figure 2). Given the prevalence of brother-sister marriage in this family and other references to Quetzalcoatl as a son of Mixcoatl, it is probable that Eight Deer Quetzalcoatl was also a child of Seven Flint Mixcoatl. Either interpretation is chronologically possible, and the two rulers would have been living about 1080-1100.

At Tula there is a column showing a bearded warrior with a bird headdress. The upright head plumes suggest that the bird may be a quetzal. Behind this, but apparently not part of the costume, is a repre-

Figure 1a. Eight Deer, King of Tula, wearing Quetzalcoatl (Feathered Serpent) name-headdress (*Bodleian*, p. 13e). Drawings for Figures 1, 2, and 6-8 are by Peter Mathews and Persis B. Clarkson.

Figure 1b. Written name of Eight Deer Feathered Serpent (*Bodleian*, p. 13d).



sentation of a snake. At Chichen Itza a younger warrior appears with the same bird headdress and a large feathered serpent behind him (Tozzer, 1957, 11). It seems clear that the latter is a name glyph of Quetzalcoatl and the quetzal-bird headdress may partially re-enforce this, but it does not completely give the name. Paintings on the Temple of the Jaguars, which show Toltec warriors fighting Mayas, include repeated representations of two kinds of giant snakes among the warriors. One of these is a typical feathered serpent (Figure 3), while the other has scrolls along its back (Figures 4 and 5). I believe that the latter represents a cloud serpent and that these are name glyphs of the Toltec rulers, Quetzalcoatl and Mixcoatl. The fact that they recur repeatedly probably indicates a different artistic convention than our own, showing important leaders at different stages of the battle. These may be the same two individuals mentioned in the Mixtec codices at about 1100 (Molloy and Kelley, 1981). It is a striking fact that in the Lower Temple of the Jaguars, warriors in Maya costume, with associated name hieroglyphs, are shown wearing feathered serpent costumes (Tozzer, 1957, 11, figs. 194, 634); here it is possible, but unlikely, that the feathered serpent is an additional name.

The difficulty of distinguishing whether a particular costume is or is not a name may be seen clearly in the Mixtec codices. A common Mixtec name seems to have been composed of the name of the Rain God (Mixtec Dzahui; Aztec Tlaloc) and an incomplete sun disk. As a separate name, the entire head of the Rain God is shown with the sun disk.

Figure 2. Seven Flint wearing Mixcoatl (Cloud Snake) headdress (*Bodleian*, p. 13e).

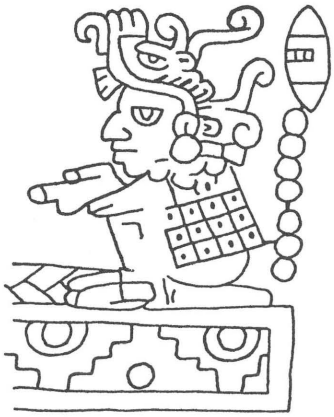
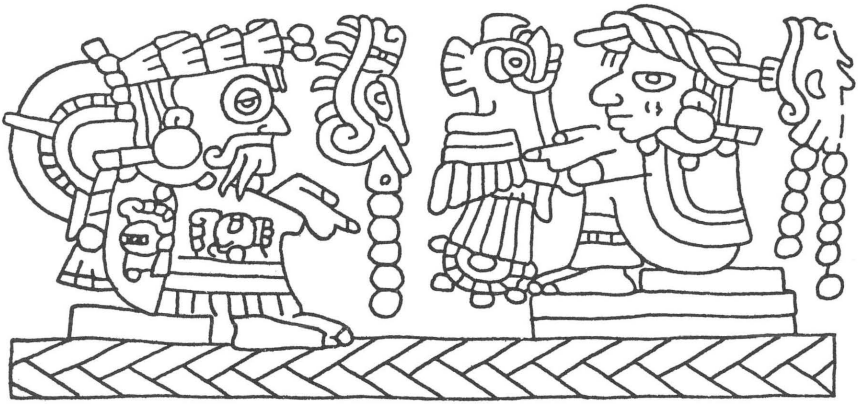


Figure 3. Quetzalcoatl with giant name hieroglyph, Structure 2D1 (Great Ballcourt, Upper Temple of the Jaguars), west wall, south section, Chichen Itza (ff. Tozzer, 1957, fig. 60).

However, when an individual with this name is shown, he is often represented wearing a Tlaloc mask with a sun disk behind him. At other times people seem to wear Tlaloc masks as an indication of status, perhaps as priests of the Rain God. Thus, the *Bodleian* (p. 7c) shows the marriage of Five Crocodile, wearing a Tlaloc mask and with a half-sun disk behind him, to Eleven Water Quetzal-Jewel (Figure 6a). On page 35c no human figures are shown, but Five Crocodile's personal name is shown by the head of Tlaloc, accompanied by a half-sun disk (Figure 6b). Clearly, in this case, the mask was worn as part of the name. On the other hand, the *Bodleian* (pp. 39b-40b) shows the early Mixtec ancestor, Five Wind, wearing a Tlaloc mask and accompanied by footsteps coming from a sky band (Figure 7). The latter give his name. His wife also wears a Tlaloc mask, but a bird-headed snake (apparently a Quetzal-snake, but depicted differently from those which accompany masculine names) appears as her personal name. Caso (1960, p. 53) points out that Five Wind's son, Five Reed; the latter's wife, Three Snake; their daughter, Thirteen Eagle, and her husband, Five Crocodile, all wear Tlaloc masks. In all cases, they have additional personal

Figure 4. Mixcoatl, with giant name hieroglyph, Structure 2 D1 (North Temple of the Great Ballcourt) (ff. Tozzer, 1957, fig. 272).

Figure 5. Mixcoatl, with giant name hieroglyph, Structure 2 D1 (Great Ballcourt, Upper Temple of the Jaguars), west wall, south section, Chichen Itza (ff. Tozzer, 1957, fig. 60).



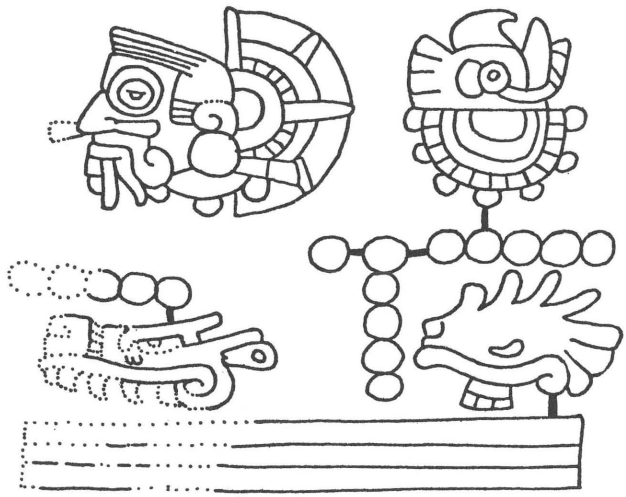


Figure 7a. Marriage of Five Crocodile Tlaloc-Sun (wearing Tlaloc mask as name) and Eleven Water Quetzal-jewel (*Bodleian*, p. 7c).

Figure 7b. Name hieroglyphs of Five Crocodile Tlaloc-sun and his wife, Eleven Water Quetzal-jewel (*Bodleian*, p. 35c).

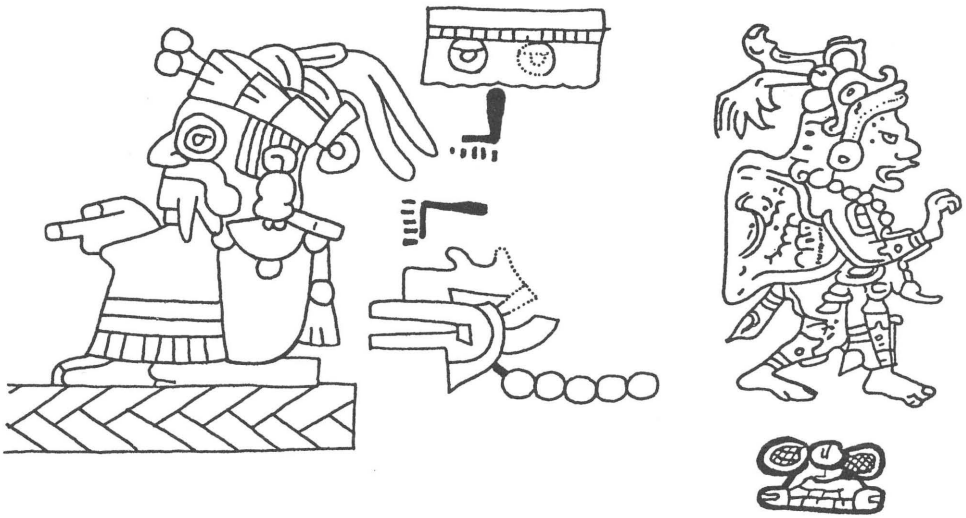
Figure 6. Five Wind Comes-from-Heaven wearing Tlaloc mask (*Bodleian*, p. 39c).

Figure 8. God N wearing turtle-shell on his back and net-bag on his head. Name hieroglyph composed of net-bag and turtle-shell below (*Dresden*, p. 60a).

name glyphs, and it seems likely that they represent a partially hereditary sequence of priests of the Rain God or mythical figures identified with him.

The same personal name, Tlaloc-Sun, furnishes a good example of another curious Mixtec practice, for the *Bodleian* and the *Selden* codices both mention rulers named Tlaloc-Sun with the calendar name One Monkey. Their genealogical connections prove that these are two different individuals about four generations apart. Apparently, in at least some cases, it was customary for people to be given personal names taken from prominent ancestors or predecessors with the same calendar name. In the case of the two One Monkeys, nothing in the costume seems to differentiate them.

This practice led Spinden (1933, p. 445) into an important chronological error. The paternal grandfather of Eight Deer of Tilantongo was a certain Thirteen Dog Eagle Star. Spinden identified him with another Thirteen Dog Eagle Star, whom we now know was Eight Deer's grandson and the ruler of Teozacoalco. The repetition of calendar name and surname together seemed, at that time, convincing evidence of identity; only the publication of the list of rulers in the *Mapa de Teozacoalco* (Caso, 1949) showed its falsity. However, adequate understanding of one item of costume would have prevented the error. Eight Deer went to Tula and was given, as a special mark of honor, a nose plug. This was inherited, presumably with the indicated rank, by his son, Four Dog, of Teozacoalco. It is Four Dog's son who is the Thirteen Dog Eagle Star under discussion and he, too, wears the nose plug. If its importance had



been recognized, this alone would have been enough to indicate that he could not have been Eight Deer's grandfather, Thirteen Dog Eagle Star, who is shown without a nose plug.

In the Maya area we have less evidence of the practice of "wearing one's name," but enough to indicate that it was sometimes done. In the *Dresden* codex (p. 60a) (Figure 8) God N is represented in a turtle shell, wearing a net on his head; his name glyphs appear as "net-turtle-shell." In the *Paris* codex (p. 6) the same glyphs appear, but the god is wearing a seashell. Finally, in the *Dresden* (p. 41) the god is shown wearing a seashell, and his glyph shows a seashell rather than a turtle shell. This is quite different from most of the other gods, whose name glyphs seldom seem to be associated with their characteristics. Representations at Chichen Itza likewise show the net and turtle shell on the body of the god, and he is frequently shown on Classic Period pottery.

The headdresses and other items worn by Mayas of the Classic Period seem more often to be associated with particular ceremonies rather than with their personal names. However, Proskouriakoff (1961, p. 83) has pointed out one clear example of a "name-headdress" on Stela 1 at Piedras Negras. Here the text shows a *katun* glyph associated with a female head, and the monument shows a woman wearing a *katun* glyph in her headdress. There is nothing to indicate certainly whether this appellative glyph should be understood as a personal name in a strict sense or as some sort of title or family name. From the way the name clause compares with other known names, I think it is a personal name. Even in this case, it is worth pointing out that the same woman, identified in the text by the same glyphs, recurs on Stela 3 without the *katun* glyph in her headdress.

It is obvious that the majority of Maya rulers do *not* wear their names (or, at least, wear them only on some occasions). A glance at the variety of headdresses worn by Shield Jaguar and Bird Jaguar, on the lintels of Yaxchilan, is enough by itself to indicate that costume, during the Maya Classic Period, tends to mark other features than personal identity. To be sure, Bird Jaguar is sometimes depicted wearing a jaguar headdress (as on Yaxchilan Lintels 6 and 43), but considering the general importance of jaguars in Mesoamerica, many other explanations are possible for these depictions. Shield Jaguar is also shown with an impressive jaguar headdress (Yaxchilan Stela 20), but the "shield" element is not recognizably present in the costume (for Yaxchilan monuments, see Maler, 1903).

At Tikal, Lintel 3 of Temple IV (Coe and Shook, 1961) and Stela 16 (Maler, 1911) show a man wearing a headdress which contains, with other representations, a skull (apparently of an animal) followed by a

"star" glyph. The associated appellative glyphs of both monuments refer to a man who has been called "moon sign ruler." The date on which I think this man was born is a significant date of the Maya Venus cycle, and both monuments are at or near significant dates of the Venus cycle. Hence it is not clear whether the headdress gives an alternate personal name (given because of Venus associations at birth and different from that in the glyphs) or whether it represents a costume worn for particular ceremonies associated with the planet Venus.

In discussion with Floyd Lounsbury, Linda Schele, and Peter Mathews (at a conference in 1974 at Dumbarton Oaks, arranged by Elizabeth Benson), we noted that at least three of the individuals whose portraits are shown on the sarcophagus of the Temple of the Inscriptions at Palenque are wearing their names as headdresses. Lady Zac Kuk, "White Quetzal," a name also known among the Mixtecs, is shown wearing a Quetzal headdress; Lord Jaguar is shown wearing a jaguar headdress; and an individual whose name glyph is the head of an animal with a snakelike mouth and jaguar spots and ears (a Snake-Jaguar, in Chol Maya Chan Bahlum) wears this curious head as a headdress. This, again, emphasizes the importance of the context in which names are used, for these same individuals appear in other portraits at Palenque in which they do not wear these headdresses. Moreover, Lady Zac Kuk's name seems to be written both ideographically and phonetically. In the latter case, no obvious connection between the name and the headdress could have been recognized if the phonetic glyphs had not been identifiable from other contexts.

It was later determined that all of the individuals depicted on the sarcophagus are shown with name headdresses, and I subsequently noted that the figures on the slabs flanking the Hieroglyphic Stairway in the Palace at Palenque also wear name headdresses.

Among the Zapotecs there are some examples of what seem to be calendar names worn as headdresses as early as Monte Alban II. A good example is the ceramic sculpture of Thirteen Water, with the glyphs incised on his headdress (Toscano, 1970, pl. 245), and with the glyph Thirteen Flint Knife on the breast; the meaning of the latter is unclear, but gods often had more than one calendar name. In other calendar systems one might have suspected that it indicated the year of birth, but Flint Knife was not a year-namer among the Zapotecs.

A possible Totonac example is the Laughing Head which has a monkey with a circle above it (Kelemen, 1956, p. 117d). The circle is probably intended as the number *one* and gives the calendar name One Monkey. The composition is very similar to the Zapotec piece, although the other elements of the style are very different.

There are a considerable number of cases where the nature of headdresses strongly suggests the possibility that they represent names, but any sort of supporting evidence is lacking. A noteworthy example may be found among the distinctive headdresses of the conflicting warriors shown at Bonampak. Other likely examples are to be found in the Temple of the Bas-Relief at Chichen Itza. However, as long as headdresses played multiple roles, and we have no other kinds of evidence, we cannot use the headdresses to give names to people. We are still dependent upon other data to distinguish "name" costumes from other types.

This is a slightly modified version of a paper presented at a 1973 meeting of the Society for American Archaeology in San Francisco.

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Biblica
Designing a New Typeface for the Bible

Kurt Weidemann

A new typeface, Biblica, was designed especially for a new German edition of the Bible. The type designs and production of earlier German Bibles were examined. A variety of legibility factors were taken into consideration to meet a required economy of space and the new production demands of a digital character generation system.

Today, half a millenium after Gutenberg, we have an over-abundance of typefaces. Some, upon their disappearance, would not be missed at all. Each new alphabet faces an existence among thousands of competing forms, where an A is an A and a Z is a Z.

There is no need to design new alphabets for aesthetic or stylistic considerations. New letterforms can hardly be improvements over existing types. At best they may be similar. We should pay our respects to the Jansons, Sabons, Baskervilles, Didots, Bodonis, and Caslons by refraining from laying hands on them to dress them up or to emulate them. Valid reasons for the design of new alphabets, however, may be found in the changing technologies of typesetting, printing production, and in specific adaptation requirements, such as alterations necessary to fit classical originals into modern character generation systems.

Such a specific design requirement was the assignment received from the German Bible Society for a new edition of the Holy Bible. The occasion was the publication in 1982 of the first Bible translation mutually sponsored by the German Catholic and Protestant Church authorities.

The commission for the design of a new alphabet is a service to the reader community moreso than to the client. It must also be a service to the graphic arts and their technological conditions and opportunities rather than to purely aesthetic form considerations. If there is art involved, it must be the ability of the designer to disregard subjective feelings and to strike intelligent compromises from all of those interdependent factors. Just like Bible typography itself, which has slowly evolved over the centuries, a Bible typeface should make no pretensions to extravagance or eccentricity. Functional problems concerning the design of a Bible typeface therefore should be solved rationally instead of artistically/emotionally.

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Figure 1. The first corrected drawings of the light, italic, and semibold weights of Biblica. These drawings were transferred to the alphabet grid of a photodisplay typesetter. Sample lines were composed and subsequently reduced to text size. After revisions in the drawings an entire trial page was composed. The letterforms and legibility qualities of the basic weight of the type style became the deciding criteria for drawing the entire type family. The trial settings first indicated that ligatures were dispensable.

Figure 2. Initial finished drawings of Biblica in a height of 120 millimeters. Letters and numerals with identical form elements were derived from a single letterform.

Figure 3. Final finished drawings of the light version of Biblica capitals. Small capitals are indispensable for quality book typography.

Figure 4. Small caps, oldstyle figures, and punctuation marks of Biblica Semibold.

A number of research activities preceded the actual design work on Biblica. Sample pages of existing Bible editions were blown up to a width of one meter and their letterforms and printing carefully analyzed. The appearance of different Bible editions varied greatly through choice of typeface, typographic arrangement, printing materials, and printing quality. However, common observations were:

1. The strokes of typefaces are generally too heavy, particularly in conjunction with mediocre printing quality.

2. Strong contrasts between thick and thin strokes result in a choppy typographic appearance and reduce reader recognition of distinctive letter characteristics. Poor printing quality causes certain letter details to print too heavily while others disappear altogether.

3. A lower-case letter with generous x-height should permit the use of a more condensed letter shape without impairing legibility.

From the assignment grew a number of detailed considerations. There was never any doubt, for example, that the typeface required for the new Bible edition should have oldstyle roman characteristics, for these reasons:

1. In phototypesetting, alphabets with bracketed serifs retain their edge definition far better than sans-serif styles.

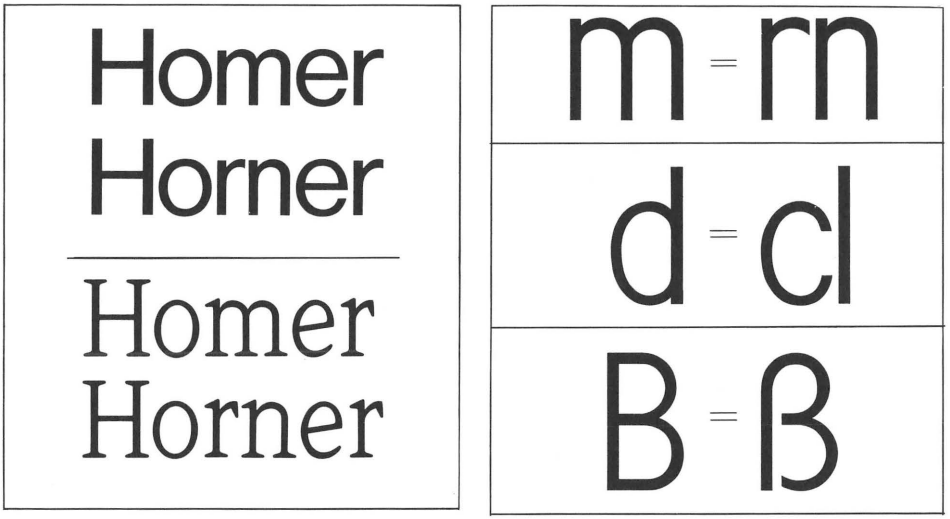

Figure 5. To achieve optimum legibility special attention has to be paid to discernability and form characteristics of individual letters, particularly those that appear with greatest frequency. Lowercase "r" and "n" combinations can more easily be mistaken for an "m" in a sans-serif style than in an oldstyle roman face.

2. The evenness of the strokes of an oldstyle roman letterform assures a more uniform typographic effect and results in reduced show-through as compared to a modern roman typeface with strong contrast between thick and thin strokes.

3. An oldstyle roman face permits a more distinctive shape of individual characters than other serifed styles.

Since Bible printing in Germany has converted to roman type from fracture types, of which there are excellent examples, problems of managing the enormous amount of text in the Bible have surfaced again and again. Designers have been hard pressed to find solutions equal to the fracture Bible: its distinctive appearance (especially the capitals), the availability of numerous ligatures, and its realtively condensed letterforms.

The German Bible Society had envisioned to fit about 3600 text characters onto a page of its new Bible edition. The German Bible consists of about 4.5 million characters, which would result in more than 1000 pages for a normal edition. In the early 1960's Hermann Zapf developed the Aldus as a narrower version of his Palatino family. To accommodate the requirements of book publishers for space economy he designed Aldus Condensed which saved between 8 and 10 percent of printing space. If the page is typographically fully utilized, the space savings of Biblica, as compared to normal book types, can amount to as much as 20 percent. This means that the Bible can become 200 pages thinner.

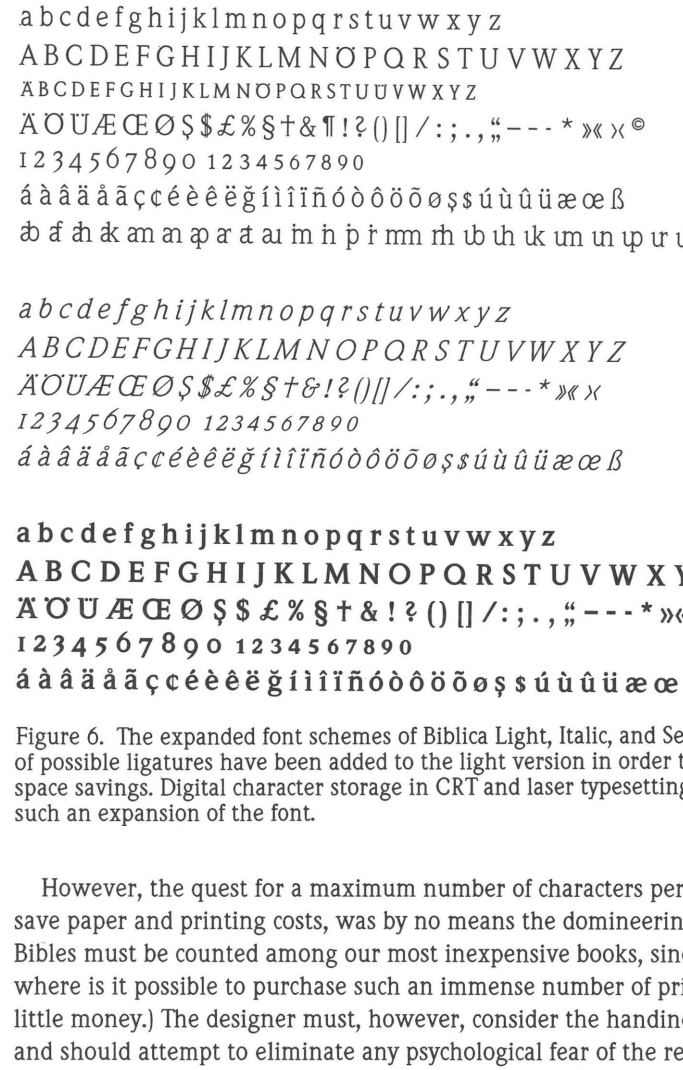

Figure 6. The expanded font schemes of Biblica Light, Italic, and Semibold. A number of possible ligatures have been added to the light version in order to test additional space savings. Digital character storage in CRT and laser typesetting systems permits such an expansion of the font.

However, the quest for a maximum number of characters per page, in order to save paper and printing costs, was by no means the domineering one. (Although Bibles must be counted among our most inexpensive books, since hardly anywhere is it possible to purchase such an immense number of printed words for so little money.) The designer must, however, consider the handiness of the book and should attempt to eliminate any psychological fear of the reader toward the very length of the Bible text. Every book, indeed, should be designed for optimum lifting and holding by the human hand.

The strokes of Biblica were generally kept light and with a minimum of contrast between stems and hairlines, so that an even, quiet appearance of the page can be obtained, inking during the printing process can be held light and, most importantly, a strong show-through can be avoided.

The mutilation of serifs during exposure, as well as the effects of photographic copying and of printing, can partially be overcome by a sturdier design. The fill-

ing in of corners (e. g., the four inside angles of the "t"), where the horizontal and vertical strokes meet, can be counteracted by a reduction of stroke thickness. Corners that are rounded off during the reproduction and printing steps must be exaggerated. (The deterioration steps of rounded corners can be measured with a microscope, and from such measurements quality comparisons for typographic reproduction can be drawn.) The human eye is capable of discerning differences in stroke width from 5 to 10 microns (5 to 10 thousandths of a millimeter), i. e., 2.5 to 5 microns on either side of the stroke. A densitometer can accurately indicate differences in gray values.

For a two-column arrangement, as required in our Bible design, 40 to 45 characters per line will still guarantee good word spacing and acceptable word breaks. The proportions of the letters, their width and height relationships, differences between counters and inside spaces and interletter spacing, relative x-height, stroke thickness, point size, word spacing, line length, line spacing (leading), and page depth are all closely dependent upon each other in determining readability qualities. The type area has to be framed by an economically feasible amount of white space and should be pleasantly proportioned. Slightly toned, off-white paper and matte inking aid legibility. Typographic variables will influence legibility more deeply than a slightly more or less legible typeface.

In the letterpress printing process of pre-electronic times the punchcutter had to foresee the effect of the impression of the raised type into the paper in his design. In photo- or digital typesetting and offset lithography or rotogravure, instability in the emulsion or exposure and changes in the light sources or the copying steps can irreparably affect the final printing of the type. To gain optimal edge sharpness and to stabilize it through all of those manifold steps is the task of the technicians. Yet type design has to counteract all known and possible sources of difficulties. So-called "aesthetic programs" in computerized phototypesetting are necessary. Yet they increase the cost of composition and should be kept to a minimum through effective type design.

Biblica was originally conceived for a specific digital character generation machine, not for half a dozen competing phototypesetting systems with an equal number of design adaptations which more or less deviate from the original design despite a common name for the typeface. Based on the premise that the letter, the word, the line, and the column present themselves to the typographically untrained eye, the initial sketches for the new Bible type were made without technological considerations. They were rendered freehand, so to speak, from the eye of the designer to the eye of the reader. The special requirements and conditions imposed upon the typeface during typesetting and printing production were tested and considered at a later stage (e. g., the sawtooth effect of the raster upon the character edges in digital composition). Controlled conversion into digital form, exposure tests, and visual and densitometric checks, after all, serve

31 Terach verließ mit seinem Sohn Abram, seinem Enkel Lot und seiner Schwiegertochter Sarai die Stadt Ur, um ins Land Kanaan zu ziehen. Sie kamen bis nach Haran und blieben dort. In Haran starb Terach im Alter von 205 Jahren.

Die Urväter Israels (Kap. 12–35)

Gott beruft Abram (Abraham)

12 Der Herr sagte zu Abram: »Verlaß deine Heimat, deine Sippe und die Familie deines Vaters und zieh in ein Land, das ich dir zeigen werde! 2 Ich will dir viele Nachkommen schenken und dich zum Vater eines mächtigen Volkes machen. So wirst du in aller Welt berühmt; an dir wird sichtbar werden, was es bedeutet, wenn ich jemand segne. 3 Alle, die dir und deinen Nachkommen Gutes wünschen, werde auch ich segnen. Aber wenn einer euch Böses wünscht, dann trifft ihn mein Fluch. Alle Völker der Erde werden Glück und Segen erlangen, wenn sie dir und deinen Nachkommen wohlgesonnen sind.«

4/5 Abram folgte dem Befehl des Herrn. Er war fünfundsiebzig Jahre alt, als er seine Heimatstadt Haran verließ. Seine Frau Sarai und Lot, der Sohn seines Bruders, begleiteten ihn. Sie nahmen ihren ganzen Besitz mit, auch die Sklaven, die sie in Haran erworben hatten, und zogen in das Land Kanaan, in dem damals noch die Kanaaniter wohnten. 6 Sie durchquerten das Land bis zu dem heiligen Baum bei Sichem.

7 Dort erschien Gott Abram und sagte zu ihm: »*Dieses Land will ich deinen Nachkommen geben!*« Abram baute dem Herrn einen Altar an der Stelle, wo er ihm erschienen war. 8 Von dort aus zog Abram in das Bergland östlich von Bet-El. Seine Zelte standen zwischen Bet-El im Westen und Ai im Osten. Auch dort baute er einen Altar und betete zum Herrn. 9 Dann zog er von Lagerplatz zu Lagerplatz immer weiter nach Süden.

Abrams Bewahrung in Ägypten
(vgl. 20,1-18; 26,6-11)

10 Damals brach im Land Kanaan eine schwere Hungersnot aus. Darum zog Abram noch weiter, um in Ägypten Zuflucht zu suchen. 11 Als er an die ägyptische Grenze kam, sagte er zu seiner Frau Sarai: »*Ich mache mir Sorgen, weil du so schön bist.* 12/13 *Wenn die Araber dich sehen, werden sie sagen: ›Das ist seine Frau‹, und sie werden mich totschlagen, um dich zu bekommen. Sag deshalb, du seist meine Schwester, dann werden sie mich am Leben lassen und deinetwegen noch besonders gut behandeln.*«

14 In Ägypten traf ein, was Abram vorausgesehen hatte. Überall fiel Sarai durch ihre Schönheit auf. 15 Die Hofleute erzählten dem Pharao von ihr, und er ließ sie in seinen Palast holen. 16 Ihr zuliebe war er freundlich zu Abram und schenkte ihm Schafe und Ziegen, Rinder, Esel und Kamele, Sklaven und Sklavinnen.

17 Der Herr aber bestrafte den Pharao und seine Familie mit einer schweren Krankheit, weil er sich die Frau Abrams genommen hatte. 18 Da ließ der Pharao Abram rufen und sagte zu ihm: »*Warum hast du mir das angetan? Du hättest mir doch sagen können, daß sie deine Frau ist! Aber du hast sie für deine Schwester ausgegeben, nur deshalb habe ich sie mir zur Frau genommen. Nun, sie gehört dir; nimm sie und geh!*« Der Pharao befahl einer Abteilung Soldaten, Abram mit seiner Frau und seinem ganzen Besitz über die Grenze zu bringen.

Abram und Lot trennen sich

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a) Zur Namensform siehe die Fußnote zu 17,4/5.
b) Dies ist wahrscheinlich der ursprüngliche Sinn. Möglich ist auch die Übersetzung: »Alle Völker der Erde werden mich bitten, sie so zu segnen, wie ich dich gesegnet habe.«
12,1: Apg 7,2-3; Hebr. 11,8 12,2: Ps 72,17 12,7: Kap. 13,15; 15,18; Jos 21,43 12,8: Kap. 4,26
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Figure 7. Trial pages composed in identical sizes of Times Roman (left) and Biblica. In a similar typographical layout Biblica possesses a noticeably larger relative type size, yet accommodates 200 additional characters per page.

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a) Zur Namensform siehe die Fußnote zu 17, 4/5.
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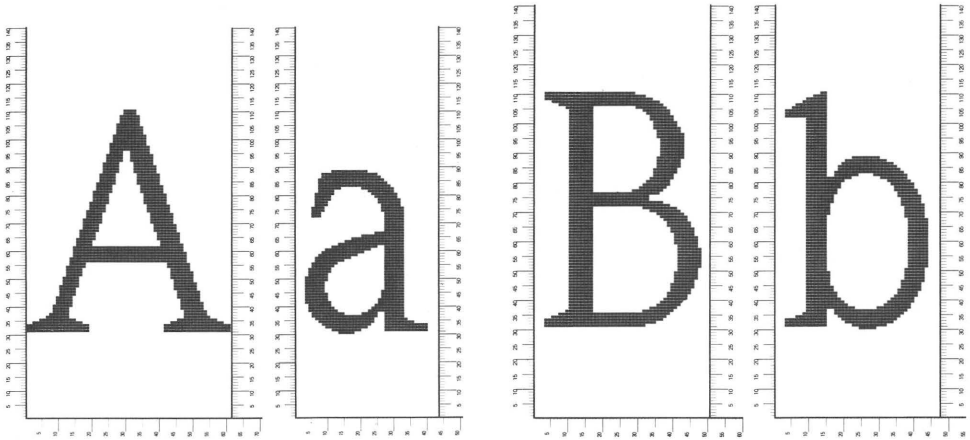
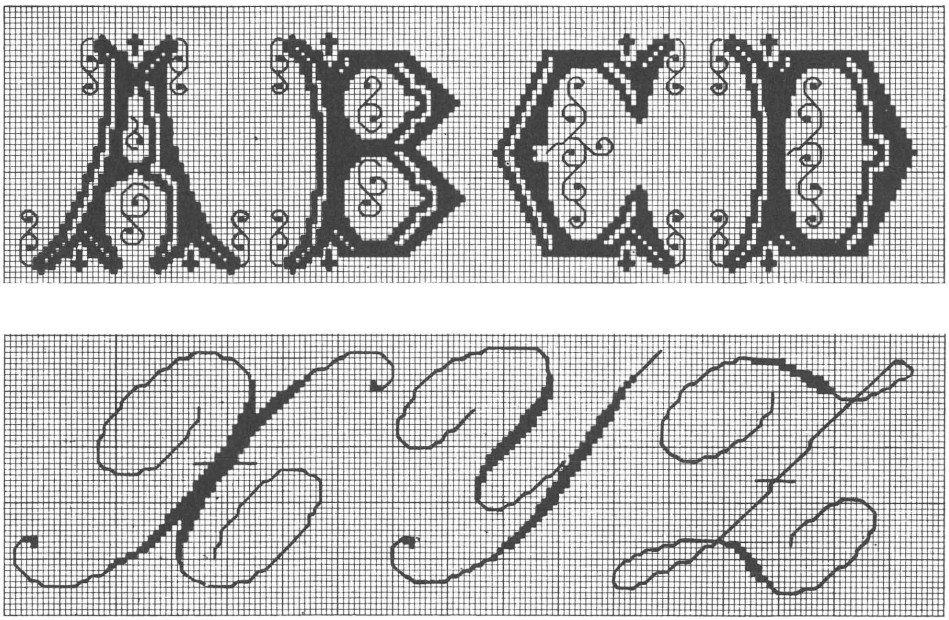


Figure 8. Digitization pattern on the basis of the master drawings. A steeper arrangement of the serifs permits rastering in uniform starsteps.

Figure 9. The principle of digitization, a binary (on-off) decision, had already been used in needlepoint patterns of the nineteenth century. These examples come from a textbook for cross-stitching published in Alsace-Lorraine around the turn of the century. Just like the binary coding necessary in digital character generation, this sample indicates the fields that have to be filled and those that must remain empty. The script face shows the problems arising when diagonal strokes are translated into a sawtooth effect.



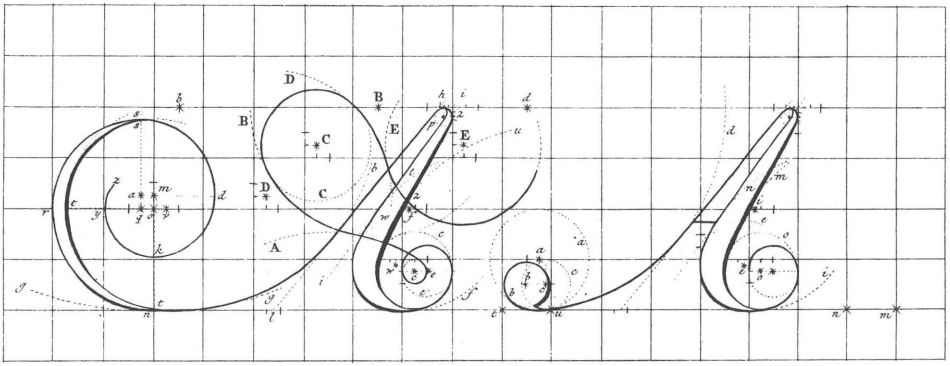


Figure 10. The Dutch writing master, Jan Pas, published a *Mathematical and Scientific Treatise on Writing* (1733) in Amsterdam. The painstaking mathematical reconstruction of circles and ellipses has difficulty in emulating the free-hand flourishes of the pen. Attempts to define type design through measurable, constructible geometric norms have been undertaken from Durer's *Of the Just Shaping of Letters* to the present. But only the breathtaking speed of microprocessors seems to free the design and variability of letterforms from most limitations.

only one purpose: to assure the optimal correspondence between eye and printing type through a faithful reproduction of the letterforms.

Since Biblica was conceived only as a text type, no letterform compromises in favor of their appearance as a display face had to be struck. During the metal typesetting era it was customary to produce large and small sizes from separate drawings. Nowadays a single size is normally reduced or enlarged. This, almost invariably, takes place at the expense of form quality in either the larger or smaller size ranges.

The use of italics for emphasis leads to a slightly reduced reading speed. For Biblica the italic is not appreciably narrower than the roman version. Italics do not frequently appear in the Bible. But the utilization of semibold display is an old Bible typography tradition. For that weight, a definite stroke thickness increase, compared to the normal text weight, is essential. It serves to structure and optically enliven the page. In addition to lining figures, the new typeface includes oldstyle numerals. Numerals appear in the Bible in sizes smaller than the text, and through their ascenders and descenders oldstyle figures are more legible than lining ones.

Biblica has only one ideal set width. It is based on the character width, the stroke weight, and the inside spaces of a type style. It may be technically easy and fashionable to letterspace and kern supertight, but white space reductions often interfere with ease of legibility. A problem is the set width of critical letter combinations. In metal typesetting days one could equalize letterspacing of handset

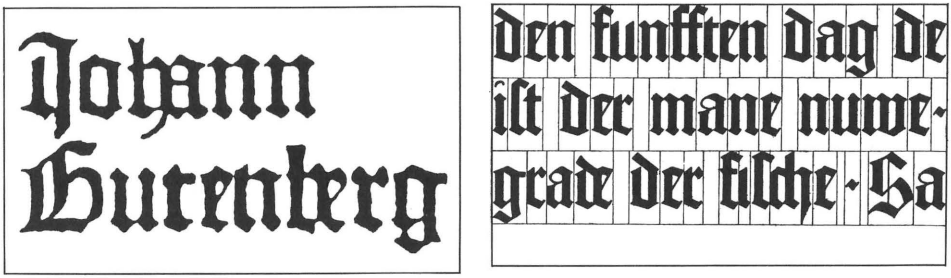
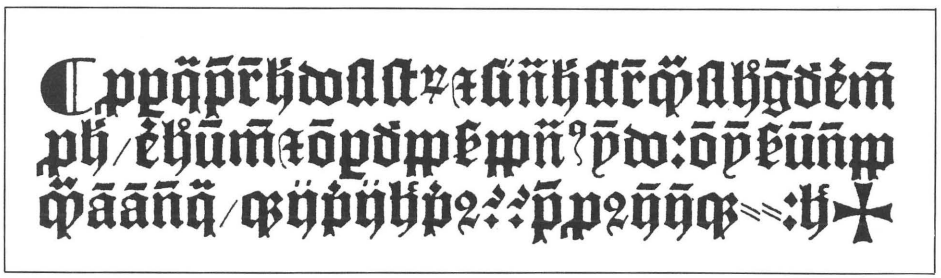


Figure 11. Ligatures "ha" and "be" in a Gutenberg type.

Figure 12. The type for Gutenberg's Astronomical Calendar of 1448, his first printed piece extant, already shows his use of different letter widths. Starting with the "i" as a single unit, one can discern letters of one-and-one-half unit width (e, r), double (n), and triple unit width (m).

Figure 13. First lines of Gutenberg's 42-line Bible (1453–55) in a facsimile type by the Austrian State Printing Office in Vienna, based on Gutenberg's original typeface. In order to achieve visually well justified lines, ligatures and omissions were accepted.

Figure 14. Type specimen of the St. Augustine flamand (Enschede, Haarlem, Holland) shows 13 diphthongs and 51 ligatures in addition to 28 lower-case characters.



type with tissue paper and thin copper spaces. The compositor exercised constant spacing control with his eyes and his hands. Nevertheless, he was unable to kern small point sizes. Unpleasant combinations as LA, butting round forms like OC, and parallel verticals like NN are less obtrusive in a more condensed face like Biblica than in alphabets which are based on more geometric shapes like squares and circles.

The limitations imposed upon font size by the number of boxes in a foundry typecase, the channels of a magazine, the positions of a matrix case of a metal typesetting machine, or the font master of second-generation phototypesetting equipment have been abolished in digital machines where additional characters can easily be stored. Since the alphabet itself cannot be expanded, the added characters can be ligatures which may contribute to a quicker comprehension of word shapes. In that respect we are returning to the beginnings of type founding. To obtain good word shapes and even line justification, there existed in some instances more than 50 ligatures from the time of Gutenberg (who had 290 characters in his typecase) to the seventeenth-century Dutch typefounders. Gleaned from the scribes, ligatures played an important role during the first century of metal type casting. In order not to impair the even gray value of a line and the uniform appearance of a page, scribes utilized a variety of contractions and omissions. After all, it was impossible for them, when they arrived at the end of a line, to achieve justification by reducing or increasing word spaces, as a compositor was able to do.

The Bible is a book with a three-thousand-year history, during the course of which human mentality and language have undergone continual changes. Its legibility therefore is of utmost importance. One can only deviate from the established forms of our system of symbols, the alphabet, in unnoticeable steps, so that the final consumer – the reader – does not become conscious of them. These deviations must not impair his interest in the contents and his reading flow. When the opportunities of an enlarged x-height and a condensation of the letterforms have been carried beyond a safe point, ease of reading and recognizability of character forms decreases rather than increases. To reach that limit without transcending it is the art of the contemporary type designer.

Biblica was designed by Kurt Weidemann. The master drawings were executed by Kurt Strecker, a long-time associate in Kurt Weidemann's studio. The digitization was supervised by Wolfgang Bauer of Bauer & Bökeler Filmsatz GmbH, Denkendorf. The director of the German Bible Society, Gernot Winter, was in charge of the assignment, assisted by his production manager, Hans Peter Sussmann.

This article has been excerpted with kind permission from *Deutscher Drucker (Satztechnische Beilage)*, nr. 34 · 22. X. 1981. The text has been set in Biblica typeface on a Digiset 400 T30 by Bauer & Bökeler Filmsatz GmbH, Denkendorf, West Germany.

Text Display by "Saccadic Scrolling"

Andrew Sekey and Jerome Tietz

A novel method of displaying alphanumeric text is described, named "saccadic scrolling." Text is flashed onto an electronic display one line at a time and remains visible until replaced instantaneously by the next line. The user has manual control over the display by either advancing it line by line or adjusting the rate of automatic replenishment. Experiments are reported in which reading speeds and comprehension for various modes of this kind of display were compared with the conventional "Times Square" type scrolling as well as with print. Single-line manual and automatic saccadic scrolling modes yielded results approaching that of print, suggesting that this type of refreshable display could become an acceptable alternative under certain conditions to hard copy. (The Times Square mode proved inferior to the others in every respect.) Suggested applications for the technique are: autotrainer for the reading handicapped, communication terminal for the deaf, and general business use.

For centuries man has taken it for granted that the carrier of written communication is paper, even if electronics played a role in the transmission phase, as in telegraphy or telex. Yet once the information recorded on it has been made use of, the paper frequently gets discarded. The process of transmitting information in the form of marks on paper thus requires materials (trees, rags, dyes), energy (to run the printing presses and for the transportation of the paper), and space (for storage). When the information recorded on the paper is transitional rather than archival, all of the above, having been only auxiliary to the communication process, become in a sense wasted. Seyler (1975) argues persuasively against the use of hard copies for transmitting and storing non-archival information, and contrasts non-interactive information systems with interactive communication systems.

The case for a volatile display is presented by Marko and Farber (1978) from another viewpoint. They call attention to the (theoretical) 100:1 mismatch between the 5,000 bits/s data transmission capacity of a telephone channel (with special coding and equalization) and the approximately 50 bits/s limit on information-processing speed of an adult reader. They recommend resolving the inefficiency resulting from the mismatch by the installation of a 1-2 Mbit storage, corresponding to 100-200 pages of text, between the communication channel and the reader. (Actually their proposed scheme, couched in terms of a

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"briefcase computer," allows the user both to receive and to transmit messages.) Short bursts of "on-line" transmissions are then separated by long periods of "off-line" reading, composing text, calculating, etc.

Given the advantages of a refreshable visual display, why not then use one presenting an entire page, as in print?

This obvious question could be countered by its less obvious opposite: why should one? After all, the notion of a "page" is inherited from printing technology, and is not germane to the process of reading text. (In contrast, single lines would not suffice for presenting graphic information.) Thus the conventional cathode-ray-tube displays are increasingly being challenged by solid-state flat panel displays (Tannas & Goede, 1978). These encompass a variety of physical phenomena, such as gas discharge, light-emitting diodes, electro-luminescence, liquid crystals, and so on (Pucilowski & Schlam, 1978). Their cost is generally a function of the display area, and so is the complexity of the driving circuit. They may be fixed-font symbols, such as the familiar 7-segment display, or consist of a matrix of "pixels" (picture elements), such as the Burroughs "Self-scan" panels.

These displays, unlike a cathode-ray tube can be manufactured in a wide range of shapes and sizes, including single lines of 40 characters or more. Furthermore, they are flat and can be driven with much lower voltages than a CRT, making them attractive for applications where portability is of importance.

The question then arises whether a single-line (or perhaps two-line) display would be acceptable for continuous rapid reading. One's first guess might be that it might not, for such an artificial restriction could well be expected to seriously impede the reader in reviewing an earlier part of the sentence, which we usually do to resolve ambiguities. In this paper we report on two experiments designed to explore this question, and on results that show definite promise for single-line displays.

Method

Objectives. The long-term goal of the research described is to explore a text display mode, believed to be novel, which we call "saccadic scrolling." In this mode, text is presented on an electronic display one line at a time, as is the "Times Square" moving news and commercial displays. Unlike these, however, which are "scrolled" from right to left in either a seemingly continuous movement or jumping one letter at a time, in saccadic scrolling an entire line remains on display for a certain period of time, and is then replaced instantaneously by the next. Such a display can be derived from the familiar scrolling process of cathode-ray

display used in computer terminals, by blocking out the view of all but one line. The resulting effect is then of new material appearing instantly in the visual field, much as it does during the fixation pauses between saccades in normal reading (Bouma & de Voogd, 1974; Rayner, 1978; Young & Sheena, 1975). It is this feature that motivated the choice of the term "saccadic scrolling."

The technical and economic justification of a single-line display lies in the cost of electronic display devices, as well as their size, weight, and power requirements. If a single-line display could be shown to be an adequate substitute for conventional multi-line ones, at least for some reading activities, then a display device would need to have only a one-line capacity, so that even complex text could be carried about in a small hand-held word processor.

Specific Aims. The experiments were aimed at comparing several modes of single- and double-line electronic displays with conventional Times Square scrolling, as well as with print. The criteria for the comparison were reading speed and comprehension. Also, subjective reports about the preference for various modes were solicited from subjects.

Two experiments were conducted, separated in time but under almost identical conditions. Experiment 1 was intended to explore single- and double-line manual and automatic modes (described below), with printed text serving as a reference condition. Experiment 2 was specifically designed to compare single-line automatic and manual modes with Times Square and conventional page-printed text.

Subjects. In both experiments subjects were recruited from university students and staff. In Experiment 1 there were 8 volunteers (3 females and 5 males); in Experiment 2, 24 subjects (8 females and 16 males) were paid $5 for their participation. All subjects were over 18 years of age, and reported having normal vision in both eyes, with correction where necessary. They were told in advance that the purpose of the experiments was to compare reading efficiency attainable for various modes of text display.

Apparatus. The two main forms of presenting text were designated *page format* (reading conventional print from a sheet of paper) and *screen format*. In the latter the text appeared as white letters on a black background of a Perkin-Elmer 1100 CRT terminal. The screen was about 40 cm from the subject's eyes, with its center slightly below eye level. The capital letters on the display were about 4.5 mm high and 2 mm wide (0.65° by 0.29° visual angle, about 50% larger than when reading average-sized print). Each line of text contained 39 (Experiment 1) or 40

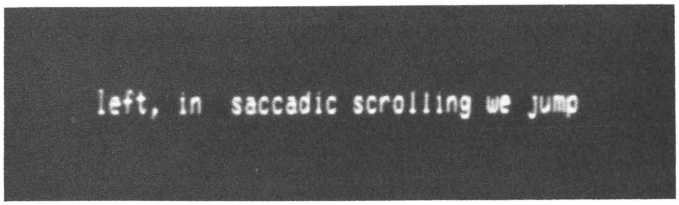

Figure 1. Single-line display on computer terminal.

(Experiment 2) upper and lower-case characters, including spaces, and was about 9.7 cm. long.

The text was made visible either one or two lines at a time, by placing an appropriate opaque mask on the CRT screen, with a slit approximately at center height. The separation between the lines in the double-line display was about 1.5 mm. A typical line of display, as it appeared to the reader, is reproduced in Figure 1.

Modes of Presentation. In the *screen format* three modes of presentation were employed: (i) saccadic scrolling, automatic mode; (ii) saccadic scrolling, manual mode; and (iii) Times Square mode.

In *saccadic scrolling* an entire line remained on display for a predetermined length of time, and was then instantaneously replaced by the next line, until the final line was displayed. Each text began with the words "ready" and "begin" on consecutive lines, followed by the first line of text. The word "end" appeared after the final line.

Shifting of text lines was accomplished in one of two ways. In the *automatic mode* the text advanced automatically at a uniform rate. This rate was determined via a counting process in the computer, and was initially adjusted by the experimenter. During the reading process, however, the subject could, by pressing the "s" key on the terminal's keyboard, augment the cycle time by a fixed number and thus slow down the display rate; likewise, pressing the "f" key made it faster. Each pressing of the key thus caused a constant increase/decrease in the rate, so that by repeated pressing the subject could adjust the rate at will to a comfortable reading speed. Furthermore, by pressing the "b" key the subject could back up to the previous line; this remained visible until the "k" key was pressed, which reinstated the automatic stepping at the rate in effect prior to pressing "b."

In the *manual mode* only two keys were needed: the key "l" advanced the text by one line at a time, while the key "b" caused it to return to the previous line. Any change in the displayed material thus required the pressing of a key.

The third mode was the conventional *Times Square* mode, in which the text appears to flow from right to left, moving one character space at a time, until the end of the passage. This was accomplished by rewriting the text with each character moved one position leftwards, causing the leftmost character to vanish and a new character to enter from the right. The subject could increase the speed of movement by pressing "f" and slow it by pressing "s." Each key press caused an increment or decrement in the apparent speed (i.e., frequency of rewriting the line with a character shift) of the text across the screen. The "b" key caused the text to reverse direction and move from left to right, while pressing "k" caused the resumption of right to left motion. As in the saccadic modes, the passage began with the words "ready . . . begin" and ended with the word "end."

Finally, in the *page format* the subject read the passage printed on paper in the STEP booklet described below.

The display and key functions were controlled by a PDP 11/45 computer. Before each trial the experimenter, seated at a second CRT terminal approximately 1 m to the left of the subject, selected the (prerecorded) text to be displayed and, when applicable, also set the initial scrolling speed. The text then appeared on the subject's terminal. The experimenter measured with a stopwatch the time taken by the subject to read each passage. After the last line of the text had been displayed (i.e., when the word "end" appeared on the screen) the computer recorded the length of time each line was displayed on the screen, the number of times the "b" key was pressed, and the numbers of text lines that were displayed via the backup key.

Reading passages (eight in Experiment 1, four in Experiment 2) were selected from the STEP (Sequential Tests of Education Progress) Series II reading tests. The passages were chosen from four different topic areas, and their average length was 470 words; they were accompanied by multiple-choice questions to assess comprehension, also taken from STEP.

Procedure. The subject was seated in front of the display terminal in a normally illuminated room (fluorescent fixtures) and was given preliminary instructions on the use of the special function keys for controlling the display. In Experiment 2 a card summarizing the use of the keys was placed directly above the keyboard. The subject was told to read as fast as possible, keeping in mind that fairly detailed questions on the text would be asked at the completion of the reading. The subject was then allowed to practice the use of the keys to speed up, slow down, and back up the text, on a practice text not subsequently used in

experimental trials. When the subject reported understanding how the keys affect the display, the trial began.

An additional purpose of the practice sessions was to determine, approximately, a comfortable reading speed for each subject, which was then set as the starting speed of display in automatic modes.

Experiment 1 was based on a balanced design having the following characteristics: (1) All subjects viewed all the passages; the order of the four topic areas was the same for all subjects. (2) Screen-format presentation of each passage was paired with a page-format presentation of another passage in the same topic area. (3) Half the subjects saw each passage in one of the four modes in screen format, while the other half saw it in page format. (4) The four different modes in screen format were cyclically rotated among the subject.

Experiment 2 also had a balanced design: (1) All subjects viewed all four passages; each subject viewed them in a different order. (2) All subjects viewed all four modes of presentation; each subject viewed them in a different order. (3) The combinations of the four texts and the four modes of presentation were cyclically rotated so that each text was combined six times with each mode, and vice versa.

The subject was told before each trial which mode would be used, so that he could place his fingers over the appropriate keys on the terminal's keyboard. He then read the text and reported when finished. Immediately after finishing, the subject was asked to answer a set of four-alternative multiple choice comprehension questions (typically 5-6 questions for each passage). There was no time limit on answering, but the subject could not refer back to the text. No feedback was given on the correctness of the answers. Completing the test took about 70 minutes (Experiment 1) and 30 minutes (Experiment 2).

Results: Experiment One

Reading Speed. The mean reading speeds averaged over all subjects for each condition are shown in Table I. The average reading speed over all four modes in the screen format, 222.3 wpm, was 14.5% slower than the 259.8 wpm in the page format, a difference which, while statistically significant ($F[1/7] = 6.4$, $p < .05$), is surprisingly small considering the gross difference in display methods and the novelty of screen format.

Though there were no significant differences among the four screen modes, some tendencies should be noted. In general, single-line displays were read faster than double lines, while the averages of automatic and manual modes are about equal. The absence of any difference in the latter is surprising, for the flexible self-pacing was expected to be more efficient than the tyrannical automatic mode.

Table I: Reading speed and comprehension scores in Experiment 1, averaged over all subjects

	Screen Format (N = 8) (Saccadic scrolling only)				Page Format (N = 32)
	Single line		Double line		
	automatic	manual	automatic	manual	
	Reading speed (words/minute)				
Mean	229.5	226.2	214.0	219.4	259.8
Std. Dev.	82.8	39.8	59.0	52.4	66.9
	Comprehension (% correct)				
Mean	81.5	61.1	55.8	69.8	74.0
Std. Dev.	23.3	25.4	25.8	31.6	27.2

Our computer program recorded the reading time for every line in each manual-mode presentation. A typical bar graph, representing a single run with one subject, is shown in Figure 2. It is evident that the subjects did vary the rate of scrolling, presumably skipping quickly over easy lines and spending more time on difficult ones. Nevertheless, this line-by-line control did not yield a significantly different reading speed from that of the automatic mode, in which a more "sluggish" control was exercised.

Figure 2. Distribution of line display times in a single experiment.

```
  .09-.22
  .23-.36          Display time ↓
  .37-.50          (seconds)
  .51-.64
  .65-.78 *
  .80-.92 *
  94-1.07 ***
1.08-1.21 ****
1.22-1.35 ************
1.36-1.49 ************************
1.50-1.63 ***********
1.65-1.77 ************
1.79-1.91 ******
1.93-2.06 *********
2.07-2.20 *
2.21-2.34
2.35-2.48 ***
2.50-2.62          →
2.64-2.76          Frequency of text
 >   2.76 *        lines with given
                   display time
n = 87
mean = 1.59
sd = 0.50
```

Table II: Reading speed and comprehension scores in Experiment 2, averaged over all subjects

	Screen Format (N = 24) (Single line only)			Page Format (N = 24)
	Saccadic		Times Square	
	automatic	manual		
	Reading speed (words/minute)			
Mean	225	206	96	278
Median	213	203	88	305
Std. dev.	66.1	56.8	36.3	60.8
	Comprehension (% correct)			
Mean	58.9	60.5	53.5	63.2
Median	50.0	67.0	58.5	69.0
Std. dev.	25.3	32.2	24.0	22.6

Comprehension. The mean comprehension scores (percentage of correct answers to multiple-choice questions) are also shown in Table I. Again, none of the differences were statistically significant in an ANOVA, but several apparent trends are worth noting. The mean score for the page format, 74%, was greater than the average for the various modes in screen format, namely 67%, in agreement with the reading speed results. Also consistent with the speed data and the subjects' reports is that the lowest comprehension was attained with the double-line, automatic method. The single-line manual, however, led to rather poorer comprehension scores than the automatic mode, even though subjects preferred the former. Within the automatic mode, there was an advantage at the 0.10 significance level ($F[1/7] = 5.12$) in favor of single-line display.

We also tabulated, for page format only, individual scores for reading speed and comprehension. The correlation coefficient is 0.36 — not significant. Considering that the group included three Ph.D.'s and a graduate student, the average reading speed (260 wpm) may seem relatively slow. However, the comprehension questions were rather difficult, and subjects soon realized that careful reading was required.

Of the total 29,550 lines displayed during the experiment, the backup key was pressed only 10 times. This was rather unexpected in view of the frequent regressive eye fixations reported in the literature (Carpenter & Just, 1978), and will be discussed later.

Results: Experiment Two

Reading Speed. The mean reading speeds averaged over all subjects for each condition are shown in Table II. Analysis of variance showed significant differences among the four means ($F[3/69] = 52.77$, $p < 0.01$). Specifically, the Duncan test showed that the Times Square mode took significantly longer ($p < 0.01$) than any of the other modes. Further, the page format took significantly less time ($p < 0.05$) than the saccadic, manual mode. There was no significant difference between the time for the page format and automatic saccadic mode, nor between the two saccadic modes.

The order of the various modes, from fastest to slowest, thus were: page format, saccadic automatic, saccadic manual, Times Square.

Of the last 15 readers (#9–#24), 10 used the backup key during the manual saccadic presentation, 6 presses on the average, and 4 used it in the automatic, saccadic method, with 7 presses on the average. Reversal in the Times Square mode was not recorded by the computer, but the experimenter observed only 2-3 instances throughout the entire test.

A comparison among the distributions of different reading times is offered by Figure 3; by far the largest variation is observed for the Times Square display.

Comprehension. The mean percent correct scores on the comprehension questions are included in Table II. While the descending order of comprehension is seen to be page format, saccadic manual, saccadic automatic, and Times Square, the differences among the means are not significant, as determined both by analysis of variance and by the Friedman two-way analysis of variance.

It would thus appear that subjects were reading with the intent of maintaining a constant comprehension, and varied their speed accordingly.

Subjects' Comments

In Experiment 1 most subjects preferred the single-line manual mode, and found the double-line mode confusing. This mode was thus omitted from Experiment 2.

In Experiment 2 when asked which of the four methods they found easiest or most comfortable, 9 subjects chose the page format. Of the screen formats, 17 subjects preferred the manual saccadic mode, 4 the automatic saccadic mode, and only 3 preferred the Times Square mode.

When asked to select the hardest to read or least comfortable mode, 15 named the Times Square, 7 the automatic saccadic, and 2 the manual

Automatic saccadic

MEAN= 2.293
SD= 0.608

FREQUENCY	0	7	14	3	0	0	0	0	0
14			*						
13			*						
12			*						
11			*						
10			*						
9			*						
8			*						
7		*	*						
6		*	*						
5		*	*						
4		*	*						
3		*	*	*					
2		*	*	*					
1		*	*	*					
INTERVAL	1	2	3	4	5	6	7	8	9

Page format

MEAN= 1.788
SD= 0.521

FREQUENCY	0	16	7	1	0	0	0	0
16		*						
15		*						
14		*						
13		*						
12		*						
11		*						
10		*						
9		*						
8		*						
7		*	*					
6		*	*					
5		*	*					
4		*	*					
3		*	*					
2		*	*					
1		*	*	*				
INTERVAL	1	2	3	4	5	6	7	8

Manual saccadic

MEAN= 2.530
SD= 0.685

FREQUENCY	0	6	12	6
12			*	
11			*	
10			*	
9			*	
8			*	
7			*	
6		*	*	*
5		*	*	*
4		*	*	*
3		*	*	*
2		*	*	*
1		*	*	*
INTERVAL	1	2	3	4

Times Square

MEAN= 5.738
SD= 2.497

FREQUENCY	0	0	3	4	4	6	4	0	1	1	0	0	1
6						*							
5						*							
4				*	*	*	*						
3			*	*	*	*	*						
2			*	*	*	*	*						
1			*	*	*	*	*		*	*			*
INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12	13

Figure 3. Distribution of reading times (in minutes) among the different modes of presentation in Experiment 2.

saccadic. The manual saccadic method was thus the overwhelming favorite, while Times Square was least liked. Typical comments about the Times Square mode were: jerky, jumpy, uneven, blurry, shaky, and fatiguing.

Discussion

While our data do not permit us to draw definite conclusions, we think that they do support the viability of a single-line electronic display. First, note that in neither experiment was there a statistically significant difference among the comprehension scores, and while in Experiment 2 page format scored highest, in Experiment 1 automatic saccadic mode performed even better. This fact, as we suggested before, may reflect a perhaps-unconscious effort on the part of the reader to maintain a fairly constant comprehension rate over all conditions. The price is paid, of course, in reading speed. However, even here the advantage of the page format was significant only against the *average* of the four screen modes (in Experiment 1), or against two of the three screen modes (in Experiment 2). This must be set against the fact that while subjects had years of experience reading in the page format, they had only a few minutes of practice in the screen format. It may therefore be reasonable to expect considerable improvement with practice in single-line reading skills.

It is interesting to relate our results to some prior research in reading. Several theories of how eye movements are controlled are discussed by McConkie and Rayner (1976), though none appear to have been universally accepted. Most relevant to our scheme, however, are regressive fixations, by which the eye takes a second look at a word or part of sentence previously read. Rayner (1978) quotes that for skilled readers typically, 10-20% of the saccades are regressive (defined here as right-to-left eye movements). Much higher figures are cited by Carpenter and Just (1978), but they employed specifically constructed ambiguous sentences which necessitated more frequent regressions than usual. In addition, their instrumentation permitted the inclusion of vertical regressions (i.e., to the preceding display line) as well. (See also: Tillson, 1955; Bayle, 1942; Rubino & Minden, 1973.)

Mitchell and Green (1978) have used a technique similar to ours but with a different constraint: each single-line display contained exactly three words. Letters were all upper-case, 0.6 cm high. No punctuation was used, except a square symbol to mark the end of each sentence. They were mainly interested in exploring reading speed variations *within* sentences as a function of syntactic and semantic variables. Never-

theless, their measured reading speed and comprehension figures were not substantially different from ours.

Their technique (as well as ours) bears a distinct resemblance to that pioneered by the so-called Harvard Films (Perry & Whitlock, 1948 & 1954) in which consecutive parts of a line are illuminated and focussed so as to guide the eye. In the course of those films the span and speed of progression are gradually increased. While the text in the films is presented in a saccadic manner, it is scanned rather than scrolled. A characteristic of saccadic scanning is the need for *phrasing* — the somewhat arbitrary choice of the length as well as extent of overlap of illuminated regions (Perry & Whitlock, 1954).

The infrequent use of the backup key in our experiment suggests that subjects were reluctant to make this much effort for the benefit of seeing the previous line again. The unpopularity of double-line display, in which the previous line was always in sight, as well as the poorer results it yielded, cast further doubt on the importance of visual access to the previous line in this mode.

Notwithstanding the above, it must be realized that the simple multiple-choice comprehension questions, while including factual recall as well as some inferences and synthesis, may not have tapped some of the higher level learning that is enhanced by instant access to large chunks of text, such as a page. Likewise, subjects could not scan forward, though for readers with poor concentration this may have been a help rather than hindrance.

Experiment 2 has clearly borne out the inferiority, in comparison with saccadic scrolling, of the Times Square mode currently adopted for such electronic gadgets as pocket calculators, translators, the Texas Instrument Speak & Spell toy, etc. (Note, however, that if characters could scroll in continuously, rather than in steps of a character width, the results could differ.) The choice between the two saccadic modes is less clear, however. Perhaps both should be made available: automatic mode for the "cruising" reader, aiming at the fastest speed yet fair comprehension, and manual mode for a more meticulous study of important messages or text, with easy backup for further scrutiny.

Potential Applications

We see the main potential application of our work in the development of a reading autotrainer — a self-contained, portable system for the electronic display under program control of alphanumeric information one line at a time. The value of such a device hinges on the basic premise that for poor readers, single-line display improves attention and can be

used as a basis for individualized literacy training. Before discussing our proposed device we shall briefly review the state of the art.

Devices aimed at increasing reading speed or efficiency by controlled rate and manner of text presentation have been available for several decades (Manolakes, 1952; Wilson & Leavell, 1957; Francis et al., 1973). Reports of their performance have been mixed, and rarely have they demonstrated a clear superiority over non-mechanical methods. Controlled readers — for example, the Craig Reader and the Tach X — employ filmstrips or slides; new material cannot readily be programmed for them. The rate of change of the display and sometimes also its direction are, however, controllable by the user. Such machines are cumbersome and cannot be carried around easily.

Shadow readers are easily portable and can be attached to most printed material with some size constraints. The reader controls the rate of descent of the shadow, but the only way the reader can pause on a particular line is by shutting off the driver. The amount of information displayed on each line is, of course, predetermined by the printed text. The transition between lines is unrealistic: the top of the current line gradually disappears while the new line seeps in from the bottom. This phenomenon has no parallel in the conventional reading mode. Also, page turning becomes a nuisance.

Reading trainers are always used in conjunction with a teacher in a learning environment. Whatever improvement they produce is not usually carried over to "real-life" reading.

By contrast, in our suggested application, the autotrainer *is* designed for independent work by the learner. A possible implementation is shown in Figure 4 and the corresponding block diagram in Figure 5. It operates as follows: alphanumeric information, most commonly narrative text, stored in ASCII format on a conventional magnetic tape cassette, is read into an elastic digital store via a controlling microprocessor. Entire lines are instantaneously transferred to the strip display and are held visible: the display is advanced either automatically at a predetermined rate of "on demand" for each line. Unlike conventional devices, the reading autotrainer can be pre-programmed and individualized; rate of presentation and regression to previous lines is under user control; equipment could be made portable and even battery operated; average reading speed could be displayed immediately upon completion of a passage; with an additional keyboard and programming the user could respond to, and be assessed on, self-evaluating comprehension questions; the trainer could be used as a "programmed manual" for step-by-step instruction on the job of slow processors of information. (A recent magazine article [Meredith, 1980] describes ongoing

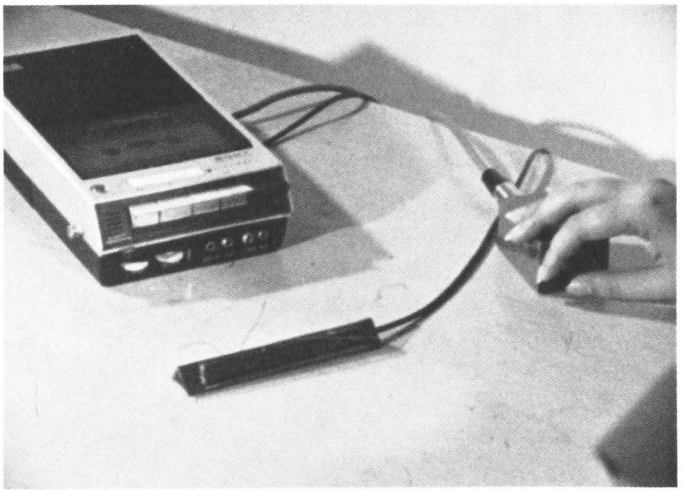

Figure 4. Mock-up of a self-contained reading autotrainer employing saccadic scrolling.

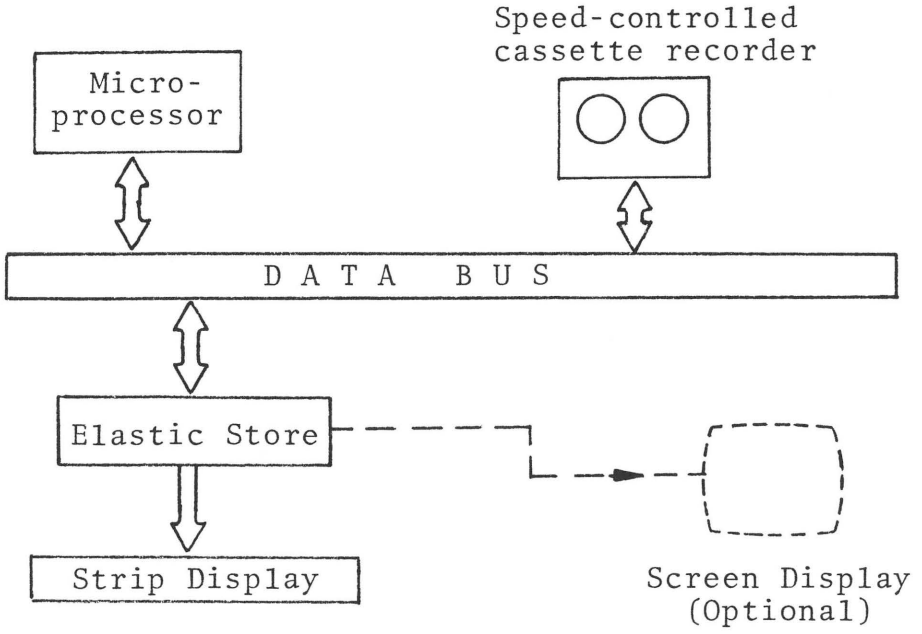

Figure 5. Block diagram of the system shown in Figure 4.

work at the California Institute of Technology by Raymond Briggs, William Rosar, and Dennis Hocevar using a 512 x 512 dot plasma screen, capable of changing 20-30 characters in a millisecond, for the study of saccadic eye motion as well as higher-level aspects of reading. Results of their work is likely to be of direct relevance to the design of the kind of device just described.)

A further application that we are considering is a telephone communication terminal for the deaf. This would be a simpler version of the Mailphone, a device currently being developed by Perceptronics, Inc. Like the Mailphone, our terminal would incorporate a touch-sensitive keyboard and a single-line display, as well as digital storage for messages. The deaf user could compose a message on the keyboard, review it on the single-line display, and only then make a telephone call for a rapid transmission of the stored message. With long messages the user could thus effect considerable saving on the cost of directly dialed toll calls by hanging up after transmission, yet use the same device in a true conversational mode whenever the cost of the call is not a factor.

Finally, we envision a device employing saccadic scrolling to be of value to proficient readers, such as businessmen or politicians, who often need to absorb rapidly the contents of urgent but volatile (i.e., non-archival) material, which may have reached them via electronic transmission. A small hand-held device using a single-line display could well meet such needs.

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Literacy for What?

Maxine Greene

We owe young people the open doors and expanded possibilities that only literacy can provide. Teaching for literacy conceives of learning not as behavior but as action — of process, of restlessness of quest. To encounter the arts and other subjects in a mood of discovery and mindfulness and rational passion is to have experiences that exclude inertness. Literacy empowers people; it is a beginning, a becoming – not an end in itself.

We hear about declining literacy; it has become a fact of life — a drab presence, simply there. We look for scapegoats: teachers, of course; disintegrating families; shiftless children; colleges rotted by relativism and relevance; ubiquitous television. We read William Safire and chortle to ourselves. After all, we reassure our cultivated friends, he speaks for us. We listen to the Underground Grammarian and wag admonishing fingers at our very own colleagues. Naturally, he is not referring to thee and me; his irony and acerbity are meant for "them." And, as we so often do in America, we go in search of the quick fix, a sure way of instilling in students what we have agreed to call "competencies" ("competence" and "capacity" no longer serve), an efficient mode of training in the basic skills. But will intense concentration on the "basics" insure what William Safire purportedly wants to hear and see? Will "competencies" bring the Grammarian above ground at last and send him on his way? What *do* we mean by literacy? What is it for?

Half a century ago John Dewey expressed the need for an articulate public and linked its emergence to a "subtle, delicate, vivid, and responsive art of communication."[1] Only when we have achieved such communication, he said, will democracy come into its own, "for democracy is a name for a life of free and enriching communion . . . It will have its consummation when free social inquiry is indissolubly wedded to the art of full and moving communication." Thirty years later Hannah Arendt wrote of humans as acting and speaking beings, disclosing themselves as subjects through their acts and words. When they speak directly *to* each other, she said, they create an "in-between" or a web of relationships.[2] Only when such a web is formed is there likely to be what she called a "public space," a space where freedom might finally appear. Jurgen Habermas, writing in the last decade, emphasized inter-

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subjectivity and mutual understanding when he described "communicative competence," which contrasts with purely technical talk geared to control.[3]

Each of these thinkers has linked communication (surely an expression of literacy) to the existence of a free society. Each has recognized the importance of authentic speaking and writing — the kind of speaking and writing that allows people to reveal themselves to others as they try to make sense of their world. When I read Dewey, Arendt, Habermas, and the many others who have probed the meanings of literacy and thought of new modes of communication and new kinds of literacy, I cannot but ponder existing instances of wordlessness and experiences of powerlessness. I cannot but ponder the *kinds* of speechlessness that occur in these times of proliferating messages and bombarding sounds: the constrained or elliptical talk of so many of the young; the technical talk of so many in the professions (including ours); the hollow kind of public utterance we hear from our nation's capital. And I remember how much language has to do with thinking, how listening to certain kinds of language can stop thinking, how difficult it is to think if one lacks appropriate words. My mind fixes on stock responses, on euphemisms and evasions, on monosyllables, on "Jordache jeans" and "Have a nice day," on the pendulum swings between gobbledygook and the solemn, impenetrable language of what often passes as expertise.

Then, for some reason, I remember Herman Melville's Billy Budd, who stutters when he is agitated. Billy can find no words to answer the evil Claggart's charge of treason, and so he strikes out at his accuser. Claggart falls to the ground, hits his head, and dies. Billy, you recall, is charged with murder and sentenced to hang from the yardarm.[4] Remembering this tale, I am compelled once more to ponder the connections between speechlessness and alienation and violence. Billy was innocent and handsome and illiterate; his shipmates loved him. But the warship, the Indomitable, was an exemplar of organized society, in which people were not supposed to listen to their hearts but to words; so Billy, wordless, had to die. I remember, too, another kind of death in Paul Nizan's novel, *Antoine Bloyé* It is the existential death of a locomotive engineer in France, a man who spent most of his life as a middle manager on the railroad system:

> Like many men, he was impelled by demands, ideas, decisions connected with his job. . . There was no opportunity to think about himself, to meditate, to know himself and know the world. He did no reading; he did not keep himself *au courant*. Every evening, before going to sleep, he opened his *Life of George Stephenson* and, having

> read through two pages, which he had got to know by heart, he fell asleep. He glanced at newspapers casually. The events they told of belonged to another planet and did not concern him. The only publications he took a vital interest in were the technical magazines with their descriptions of engines. For a space of fourteen or fifteen years, there was no man less conscious of himself and his own life, less informed on the world than Antoine Bloyé. He was alive, no doubt; who is not alive? To go through the motions of life all you need is a well-fed body. He, Antoine, moved and acted, but the springs of his life, and the drive of his actions were not within himself.[5]

And the narrator asks, "Will man never be more than a fragment of a man, alienated, mutilated, a stranger to himself?" And I think about naming the world and making sense of it; about the place of literacy in reflective and tonic living, in overcoming automatism, wordlessness, and passivity.

Of course fundamental skills are needed: knacks, know-how, *modi operandi*. But I want to see the means of achieving literacy made continuous with the end-in-view, and I would also remind teachers that *literacy ought to be conceived as an opening, a becoming, never a fixed end*. I believe, with Dewey and Gilbert Ryle, that fundamental skills are only the foundation, the first level, and that learning does not actually begin until people begin teaching themselves. Ryle talks about the importance of advancing beyond low-level skills and employing them in higher-level tasks that cannot be done without thinking. He talks of an ordinary, "unbrilliant, unstupid boy" learning to read:

> He learns to spell and read monosyllables like "bat," "bad," "at," "ring," "sing," etc., and some two-syllable words like "running," "dagger," and a few others. He has not been taught, say, the word "batting"; yet soon he is reading and spelling unhesitantly the word "batting"; and he may say, if asked, that he learned from himself how the word looks in print, how to write it down, and how to spell it out loud. In a sense, he has taught the word to himself without yet knowing it.[6]

His teacher had taught him how to read monosyllables and some longer words. Thus the teacher had empowered him to make some independent moves on his own, to make specific applications himself, in the hope that eventually he would transform what he had learned into a personal method of operating by his own "self-criticized practice." Another point is that the boy will learn untaught things if he needs them somewhere, if they respond to questions he is provoked to ask for himself. Ryle says that teaching ought to open gates, not close them; people only begin to learn when they go beyond what they are taught

and begin teaching themselves. This is teaching, in my view: creating situations that impel people to reach beyond themselves, to act on their own initiatives. And teaching, too, includes enabling persons to perceive alternative realities, more desirable orders of things. Only when they can see things as if they could be otherwise, are they free in any meaningful sense. Only as they can imagine a better condition of life, are they able to perceive what is lacking in their present moments and to reach forward, to go beyond.

This view of teaching is very much at odds with the approach taken in many classrooms today, especially in those which concentrate on competencies. Teachers are schooled to think of students as reactive creatures, behaving organisms. Overaffected by the technical ethos, they are likely to focus on measurable or observable performance or to function according to what Ryle calls a "crude, semi-surgical picture of teaching as the forcible insertion into the pupil's memory of strings of officially approved propositions. . . ."[7] When the reward system of a school is geared toward guaranteeing certain predefined performances or the mastery of discrete skills, teachers too often become trainers—drilling, imposing, inserting, testing, and controlling. They are too distanced from their students to talk with them or to them. Instead, they talk *at* them, work *on* them very often, but not *with* them. Teachers who conceive their students as some plastic raw material, or some sort of resistant medium, cannot think of empowering students to learn how to learn, to articulate, to be with one another, or to develop an "in-between."

Teaching for literacy conceives learning as action rather than behavior. The notion of action involves the reflective taking of trying out what has been learned by rote, acting on the so-called competencies. This is in contrast to an unreflective, semi-automatic movement through predefined sequences of what is sometimes optimistically called "mastery." A concern for beginnings, for action rather than behavior, is different from a preoccupation with end points, with predetermined objectives. Indeed, once teachers approach their students as novices, as newcomers[8] to a learning community extending back through time and ahead into a future, they may well open themselves (as well as their students) to all sorts of untapped experiential possibilities.

The notion of the aesthetic and the importance of the humanities unite in moving people to learn how to learn in this way. "Rooted in language and dependent in particular on writing," writes the Rockefeller Commission on the Humanities, "the humanities are inescapably bound to literacy."[9] And, a few lines later: "In literature and the arts,

the imagination gives public expression to private experience." When we work to promote what is called aesthetic literacy, an informed awareness of works of art or works in the humanities, we start with the assumption that the more a person can come to know, the more he or she will come to see and hear, certainly where works of art are concerned. We start, too, with the idea that there is no way to realize a work of art, to make it live in a person's experience, if that person is not actively involved with it. It is important to recognize that every encounter with a work of art represents a new beginning, even if the work is moderately familiar and has been encountered before. Every time we become present, say, to a Cézanne painting or an Emily Dickinson poem, we are — whether consciously or not — about to experience something new. Whoever we are, we are at a particular point in our life history; we are different from what we have been, even a day before. (And I want to stress the great importance of feeling oneself to be in process, to be on the way, to be *en route* to what is not yet.)

It may be that we have learned more, over time, about what it signifies to look at a painting, to attend to its forms, to see its contours emerging, to engage with its thrust of color or illusions of space. Having thought about it, having questioned it (and ourselves, perhaps), we shall be able to see differently, to see more. And, strangely, we may discover — if we allow ourselves to do so — that every time we come to a Cézanne painting or an Emily Dickinson poem, there is always more to be seen, if we are willing to think about it, to think about our own thinking with respect to it. We can never exhaust it, never use it up. To enter into it imaginatively, to shape the materials of our experience in accord with it, is to find something in our memory, in our consciousness, even in our lived situations that we might never have found were it not for the painting or the poem and our changing awareness of it. It can never be wholly absorbed; it can never be complete. There is always, always more.

I emphasize all this not simply because I believe that the arts should play a central role in the schools. It happens that I *do* believe this passionately, knowing as I do that aesthetic experiences are not only affective and intuitive, knowing that they involve persons perceptually and cognitively as much as they do emotionally, knowing that they provoke people to wide-awakeness and to posing questions and pondering their worlds. To be able to attend to the shapes of things and their qualities, to pay heed to sounds, to be in touch with the rhythms of the world: All of this is to be more alive, more open, more resistant to stasis and to all that stands in the way of literacy. But my emphasis on the connections between the arts and literacy also suggests so many things about how

teaching in many realms might proceed. I mean the kind of teaching that moves young people to search, to reach out, to think (as Dewey often said) prospectively and as participants. I mean the kind of teaching that enables persons to be observant and imaginative and careful, awake to their own lived worlds and what is deficient about them.

To encounter the arts and other subjects in a mood of discovery and mindfulness and rational passion is to have experiences that exclude inertness. Students experience inertness when they are confronted with information that is solidified, packaged, and in some way dead: pieces of what is incorrectly called knowledge, something students are expected to insert into their minds. Such a barren approach to teaching or to communication can only discourage thinking and mindfulness. (I anticipate with some horror the advent of videodiscs and additional cable networks if we cannot countervail against this.) After all, the value of what we come to know is subordinate to its use in thinking; and inert ideas all too often stop thinking in its tracks.[10] All of us can recall people (not only children) who say, "I know, I know," meaning that they do not want to think about something. All of us are familiar with the kind of certainty that makes people feel there is no more need to think, and we are familiar with the numbing effect of packaged media messages and categorized "information."

In an encounter with a work of art, the *point* of knowing something about form and color or imagery and meter is to allow what is being attended to to grow in our experience. Simply to store a piece of information about Cézanne's effort to restore structure to the visible world is not to come to know or to learn; nor is it to heighten understanding or to enable oneself to see. The discipline required and the rigor involved are what make freedom in the quest for meanings possible. The point is to nurture the thinking process, the sense-making process — not to move people to say, "I know, I know" and switch the dials or turn off the set.

The notion of literacy of which I am speaking is a notion of process, of restlessness, of quest, I recall Virginia Woolf writing about how much of her childhood contained what she called "a large proportion of cotton wool," meaning that much of it was not lived consciously. But she also writes about "exceptional moments." She remembers looking at a flower and suddenly seeing the flower as part flower and part earth; and she put away that thought to save. She captured an elusive insight in the net of language. It is the pleasure to be found in making new connections, the insight to be gained in discovering the relations between what is perceived or understood and what follows from it. It is, as Woolf said, the "token of some real thing behind appearances; and I

make it real by putting it into words. It is only by putting it into words that I make it whole. . . ."[11] It is the significance of discovering an interest, a concern that links one human being to another. All of these cannot but illuminate ongoing experience and expand the spheres of potential meaning.

Surely there are flowers and the equivalents of flowers in the sensed and perceived worlds lived by students: flowers and faces and city streets and burned-out storefronts and other people — phenomena to be attended to as Virginia Woolf attended to what was happening in her world. There are *lived actualities* that raise questions not now answerable, thoughts to be put away in the mind, to be reconceived and reexamined and, later on, explained. Let me emphasize my concern for consciousness and the linking of consciousness to thinking and explaining. To feel passive or powerless is to be open to the despair and horror most of us (including our children) know all too well, perhaps particularly in the cities, but actually across our entire nation.

One of the important contributions to be made to the initiation into articulateness, into literacy, is the overcoming of this sense of powerlessness. Virginia Woolf did this by putting her experiences into words, but I do not think it necessary to be a writer to do so. We must do all we can to enable the young to articulate, to express what they see and hear. They need to be empowered to give voice to what horrifies them, what dulls and deadens them — by telling their stories aloud, writing logs, keeping journals, inventing fictions, creating poetry, editing newsletters, or even rendering what they perceive through paint or gesture or sound. To speak through one of these several languages is not only a way of overcoming passivity; it is a way of being free along with others, because to speak or to express is to give public form to private awareness, to communicate what is known. It is to develop the power Virginia Woolf talks about: the power against nonbeing and loneliness — the "nondescript cotton wool" that obscures so much of life.

Yes, the silence and the powerlessness must somehow be overcome, if literacy is to be achieved. The teacher of literacy, to be authentic and effective, must be inquirer, discoverer, critic, sometimes loved one. He or she must be someone who cares, someone who is ready to engage a subject matter or a created form as an always open possibility. The true teacher of literacy is not the kind who comes to class having "done" *Romeo and Juliet* or the history of the Civil War or the science of genetics — with all questions answered and the subject turned into an object ready to be consumed. Rather, he or she must be prepared to think critically, giving good reasons for the claims made and even the demands, encouraging students to look critically upon the perform-

ances in which they are asked to engage, participating in discussions with the students, making explicit the norms that govern their being together, keeping the enterprise open, allowing for possibility. Of course it is a burden for the teacher; but meaningful literacy is most unlikely if teachers do not display, against all odds, the modes of being (and of foresight and integrity) they wish students to choose for themselves.

Our task is to move young people to be able to educate themselves and to create the kinds of classroom situations that stimulate them to do just that. Doing so, they may find themselves in a position to discover and use certain of the concepts that enable literate human beings to impose order and meaning on inchoate experience. Concepts are perspectives of a sort; they are clusters of meaning. They empower persons to organize experience in order to interpret it, to have some power over it, to see and, yes, to say. To achieve literacy is, in part, to learn how to think conceptually, to structure experience, to look through wider and more diverse perspectives at the lived world.

Obviously, in many schools the public emphasis is on literacy, basic skills, and test results, and there are administrators throughout the U.S. who care mainly about numbers and what is finally quantifiable. And there are abstracted faces in classrooms, young people for whom school is far less important than television or pop music or life on the streets. It is certainly true that, for children who look at television six hours a day, school cannot be interesting or relevant. For one thing, school makes demands that TV does not; it makes people feel inferior, as TV seldom does; it does not seem concerned with "real" things.

It seems evident that, if the school's primary function is to countervail against all of this, the literacy it attempts to make possible must be linked to critical reflectiveness, to wide-awakeness. Indeed, I insist that no other institution or agency in society has that particular responsibility. If we in education do not succeed in accomplishing this mission, we shall (as most of us are quite aware) leave a population passive, stunned, and literally thoughtless in front of television or with miniature speakers in their ears. They will become increasingly fearful in the face of what they see happening in "the world," increasingly confused by the idea of a movie actor playing President, increasingly numb to terms like "El Salvador" and "budget" and "defense." Horror, despair, passivity, and nondescript cotton wool. We have only to offer the power that comes with the ability to explain, to locate, to conceptualize, to perceive possibilities. That, as I see it, signifies literacy.

Let me conclude with a section from Ntozake Shange's choreodrama, *For Colored Girls Who Have Considered Suicide When the Rainbow Is Enuf,* because it deals with the theme of this article and because it suggests so very much.

de library waz right down from de trolly tracks
cross from de laundry-mat
thru de big shinin floors & granite pillars
ol' st. louis is famous for
i found toussaint
but not til after months uv
cajun katie/ pippi longstockin
christopher robin/ eddie heyward and a pooh bear
in the children's room
only pioneer girls & magic rabbits
& big city white boys
i knew i wazn't sposedta
but i ran inta the ADULT READING ROOM
& came across
TOUSSAINT
my first blk man
(i never counted george washington carver
cuz i didn't like peanuts)
still
Toussaint waz a blk man a negro like my mama say
who refused to be a slave
& he spoke french
& didn't low no white man to tell him nothin
not napolean
not maximillien
not robespierre
TOUSSAINT L'OUVERTURE
was the beginning uv reality for me
in the summer contest for
who colored child can read
15 books in three weeks
I won and raved abt TOUSSAINT L'OUVERTURE
at the afternoon ceremony
waz disqualified
cuz Toussaint
belonged in the ADULT READING ROOM[12]

It did not matter. She loved Toussaint. She took him home, and he became her imaginary friend. And she walked with him and explored with him and talked to him, until finally she met a boy named Toussaint Jones who turned out to be not too different from her Toussaint; but this one spoke English and ate apples and was all right with her: "no tellin what all spirits we cd move down by the river." And the section ends, "hey wait."

Would such a person *not* master the basics, with the Adult Reading Room in sight? I ask myself how we can create situations that might

release persons to take the kind of leap that girl took — away from the magic rabbits of the children's room to the Adult Reading Room. No one could have predicted that that child would find Toussaint; but I want to believe that there is *always* a Toussaint waiting there ahead, if we dare to think in terms of beginnings, to see from the vantage point of the beginner, the seeker — instead of seeing from the vantage point of the system or the bureaucracy or the framework. What supervisor, principal, testmaker, or other functionary could possibly predict a little girl's making that run into the Adult Reading Room and finding the beginning of her reality that way, making connections, reading 15 books in three weeks? But, from the vantage point of that 8-year-old, why not? And when she says, "hey wait," we know she has that sense of incompleteness that will impel her on, and we know no measurement scale can grasp that either. But think what she will have thought. Think about her gains in literacy.

We owe young people that sort of discontent, as we owe them visions of Adult Reading Rooms. We owe them the sight of open doors and open possibilities. We need to replace the drab presence of declining literacy with images of flowers and new realities. Literacy, after all, ought to be a leap.

1. John Dewey, *The Public and Its Problems* (Chicago: Swallow Press, 1954), p. 164.
2. Hannah Arendt, *The Human Condition* (Chicago: University of Chicago Press, 1958), p. 183.
3. Jurgen Habermas, *Communication and the Evolution of Society* (Boston: Beacon Press, 1976), pp. 26-29.
4. Herman Melville, "Billy Budd, Sailor," in *Billy Budd, Sailor and Other Stories* (Baltimore: Penguin Books, 1967), pp. 317-409.
5. Paul Nizan, *Antoine Bloyé* (New York: Monthly Review Press, 1973), p. 113.
6. Gilbert Ryle, "Teaching and Training," in R.S. Peters, ed., *The Concept of Education* (New York: Humanities Press, 1967), pp. 105, 106.
7. Ibid., p. 108.
8. Hannah Arendt, *Between Past and Future* (New York: Viking Press, 1961), p. 185.
9. *The Humanities in American Life,* Report of the Commission on the Humanities (Berkeley, Calif.: University of California Press, 1980), p. 69.
10. Alfred North Whitehead, *The Aims of Education* (New York: Macmillan, 1957), pp. 1, 2, 20-23.
11. Virginia Woolf, *Moments of Being: Unpublished Autobiographical Writings,* Jeanne Schulkind, ed. (New York: Harcourt, Brace, Jovanovich, 1976), p. 72.
12. New York: Macmillan, 1977, pp. 25, 26.

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Improving the Legibility of Textbooks: Effects of Wording and Typographic Design

Dirk Wendt

It has been demonstrated that the success achieved in a previous study by means of a "visualized" version of a physics textbook lesson was not so much due to typographic changes as to changes in wording that were necessary to fit the text into the new format. These changes in wording are further analyzed.

In a previous study (Wendt, 1979) we found an improvement in the legibility of a physics textbook lesson through changing the typographic design from a one-column standard design to a "visualized" version, both in speed of reading and in comprehension as measured by means of an achievement test.

This successful (visualized) version, designed by Becker/Heinrich (1969), organized a double page into four columns (i.e., two on each of two opposing pages) containing: (1) basic information on general principles, (2) additional explanation and experimental demonstration, (3) figures, and (4) fringe information — e.g., historical remarks, glossary, practical applications, problems for the student to solve. With a text printed in this format, the student can work vertically or horizontally through the lesson as he pleases, going left to right, from general principle through experimental demonstration, and from picture to practical application, or vice versa, from right to left. To design the visualized version according to these principles, it was necessary to rearrange and change the wording of the original text. Thus, in the experimental design to the previous study, two experimental variables were confounded: typographic design ("visualization" vs. standard format) and wording of the text, such that it was finally impossible to say which variable was responsible for the improvement achieved.

In the study reported here we tried to separate these two variables. We had printed an additional version ("E") which contained the same text as the visualized Version ("B" in the previous study) but in standard layout with two columns on each page. We compared this to the visualized Version ("D") and to the original two-column Version ("B").

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Thus we have, in total (including the versions tested only in the 1979 study):

Version A: standard text in standard layout with one column on each page, figures lined up at the top.
Version B: standard text in standard layout with two columns on each page, otherwise like Version A
Version C: standard text in one column on each page but with additional spaces between phrases according to the syntactic and semantic structure of the text
Version D: new text in visualized layout by Becker/Heinrich, as described above
Version E: new text (as in Version D) but in standard layout (as in Version B)

Experimental Procedure

Everything was done in the same manner as in the previous study; we even approached the same secondary schools (but, of course, used different students). We used a total of 346 students in ten classes from grades 5 to 7 (age about 12–14 years) in three secondary schools (Realschulen) in Niedersachsen, F.R. Germany.

The experimental procedure took about 90–100 minutes per session (two regular school lessons plus the recess time between them). The experimenter explained the scope and purpose of the experiment to the students and gave them, then, an achievement test on the contents of the lesson to be read (on magnets) to measure the knowledge they had already before reading the lesson, and some silent demonstrations of experiments described and explained in the text to be read.

Each class was then divided at random into three groups of almost equal size, and all members of each group were given the same version of the experimental lesson (Version B, D, or E), face down on the desk in front of them. At a sign given by the experimenter, they all started reading their text, and raised their hands when they had worked through the text and thought they had learned everything that was in it. They were told that there would be a second achievement test on the text, and that *accuracy* of knowledge was more important than speed of reading. When a student had finished reading and raised his hand, the experimenter or a helper recorded the student's reading time, took away the printed lesson, and handed him the second achievement test, which was collected upon completion. Finally, each student was shown three different versions of the lesson ("A" one-column standard layout, "B" two-column standard layout, "D" visualized layout), and asked to rank-order them according to his preference.

Results

The dependent variables in this study were reading time and the difference in achievement test scores before and after reading the experimental lesson. These were analysed by means of analyses of variance. Mean reading times (in minutes) and mean gain in achievement test scores for the three different versions are shown in Table I, together with the respective standard deviations. Results of the respective analyses of variance are shown in Tables II and III.

They indicate that both experimental Versions (D and E) were read significantly faster, and resulted in significantly larger achievement gains than the original Version (B), but the visualized Version (D) was only slightly faster than the Version (E) with the same text but in standard layout. The difference between the experimental Versions (D and E) both in reading time and in achievement gain is statistically not significant, i.e., it may as well be random. In the new study, average reading times are shorter, but average achievement gains are smaller than in the previous one, although still within the range of variation between classes. As in the previous study, this was the main source of variation. Also, in spite of the general trend indicated by the overall means for the various versions, some classes did better with different versions than others, resulting in interactions between versions and classes which cannot be interpreted systematically since the classes were selected at random. Table IV shows the results of the preference rank-ordering: as in the previous study, an overwhelming majority favored the visualized Version D.

Discussion

Apparently, both the shorter reading time and the better achievement reached with the new Version D in the previous study were due less to typographic improvement and more to changes which had been made to the text to fit it into the new format—a kind of by-product in the previous study. Thus, it seems to make sense to take a closer look at what was actually changed from the original Version (A or B) to the improved Version (D or E). First of all, it had become shorter: 1300 words instead of 1710 in the original text. This accounts for the improved reading time; actually it is almost the same if measured in words per minute rather than by overall reading time: 1710/14.55 = 117.53 wpm for the original, 1300/12.21 = 106.47 wpm for the revised Version E, and 1300/11.09 = 117.22 wpm for the visualized Version D.

However, this does not explain the better achievement gained with the revised version (unless you assume that students learn more with

Table I: Means (M) and standard deviations (SD) of reading time and achievement gained with three different versions

Version	*Reading time*		*Achievement gained*	
	M	*SD*	*M*	*SD*
original two columns ("B")	14.55	30.52	1.77	4.73
visualized ("D")	11.09	15.37	2.45	4.01
Text of "D" in layout of "B"	12.21	14.24	2.58	4.65

Table II: ANOVA of reading times

Source of variation	*SSQ*	*df*	*MS*	*F*	*P*
between Versions	591.15	2	295.58	21.69	<0.01
between classes	2117.23	9	235.25	17.26	<0.01
interaction	625.01	18	34.72	2.55	<0.01
error	4306.57	316	13.63		

Table III: ANOVA of achievement gain

Source of variation	*SSQ*	*df*	*MS*	*F*	*P*
between Versions	26.91	2	13.45	3.65	<0.03
between classes	242.68	9	26.96	7.32	<0.01
interaction	91.41	18	5.08	1.38	~0.14
error	1164.71	316	3.69		

Table IV: Results of preference ordering

Version	*Frequency of rank* 1	2	3
A, one column per page	33	106	139
B, two columns per page	37	139	100
D, "visualized"	207	30	38

Table V: Evaluation of our texts by Schulz von Thun

	Simplicity	*order/ structure*	*brevity/ conciseness*	*stimulating addition*
original text	+1	+1	0	0
revised text	+1	+2	+1	−1

shorter texts). In rewording the text for the visualized experimental Version (D) in the previous study, we did not try to produce a text which was less understandable than in the original one: we tried our best, and apparently succeeded more than we wanted to, i.e., produced a better one.

The German literature on educational psychology contains an evaluation system for instructional texts, by Langer (1971) and Schulz von Thun (1973). Because this system has proved to be useful in series of experimental studies (Schulz von Thun/Berghes/Langer/Tausch, 1974; Schulz von Thun/Langer/Tausch, 1972), it seemed appropriate for an evaluation of our experimental texts. The system consists, in principle, of ratings on four scales (or "dimensions"): (1) Simplicity *(Einfachheit)*, (2) order/structure *(Gliederung/Ordnung)*, (3) brevity/conciseness *(Kürze/Prägnanz)*, and (4) Stimulating additions *(zusätzliche Stimulanz)*. Higher ratings on the first three of these four scales are assumed to indicate better understandability of the text rated, whereas "stimulating additions" are supposed to have a more motivational effect (too many may distract from the main objective and thus decrease understanding).

Since the training of raters to evaluate texts on these four scales takes some time and effort, and to be certain of securing the ratings intend-

ed by the authors of this system, we asked one of them, Friedemann Schulz von Thun, to evaluate our texts on his scales. The results are shown in Table V. These ratings indicate that our revised text contained fewer "stimulating additions" (it had to because it is shorter!), but had gained not only on the "brevity" dimension but also in "order/structure."

Thus, after all, the improvement found with the new typographic layout (Version D) in our previous study may be due to the rewording of the text which was necessary to fit it into the new format. This, however, does not account for the success of the visualized Version (D) on the students' preference scale, as found in the previous study and reproduced here in Table IV.

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Book Review

A.S. Osley. *Scribes and Sources: Handbook of the Chancery Hand in the Sixteenth Century.* London: Faber & Faber, Ltd., 1980. 272 pp. 22 b/w illustrations. £ 16.00.

"This book is about handwriting" is the appropriate opening sentence. The distinction between handwriting and calligraphy is an important distinction to make, and one may wonder why author A.S. Osley does not make it explicitly. The more so since he deliberately omits the word "calligraphy" through a book of nearly 300 pages on the subject of scribes and sources. He seems to take it for granted. Yet the distinction is important to make precisely because it is not self-evident, and many readers may not be clear about it.

The writing-masters themselves never use the word calligraphy and were only "sometimes compelled to draw with our pens rather than to write" (P. Hamon, *Scribes,* p. 223). And that is presumably why the word calligraphy does not "thunder in the index" either: it is altogether absent. In fact, it does appear in the book — once (p. 231) — in B. Wolpe's comment on Peter Bales's *The Writing Schoolmasters:* "This book consists of three parts: Brachygraphie, Orthographie, and Calygraphie or 'Faire Writing.'" Wolpe draws our attention to the fact that no plates are included, but he fails to register that in 1590 Bales may well have been one of the very first, if not the first, to use in print the word "calygraphie." This is a point worth stressing, because it was a matter of priorities even for the writing-masters themselves: handwriting was, as it is even today, a matter of service, of utility, of serious business; calligraphy could be a matter of amusement — which it still may be — but with a difference. One thing is clear from the book under review: the writing-masters were not amused.

Handwriting is truly a small accomplishment, totally out of proportion with the limitless consequences it has on our personal and intellectual lives. It can be acquired in a matter of weeks, or even days, but we are involved with it for the rest of our lives. It is a subject generally neglected and badly practised, primarily because it has been so badly taught, apparently in any period of history. The boring, acrimonious pedantry of Renaissance school-masters is proverbial, as any reader of Erasmus, Rabelais, Molière, La Fontaine, and Osley knows. If writing-

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masters could have been "Reformed" too, surely the names and the works of Poggio, Salutati, Niccoli, San Vito, Sinibaldi, and Sallando would be as familiar in a never-neverland of universal penmanship and calligraphy as are the names of Giotto, Sassetta, Fra Angelico, Botticelli, Filippino Lippi, *e tutti quanti preraffaelliti.* And nobody would be hurt.

The history of handwriting being coextensive with recorded history, the reader should be mindful of the fact that this book covers only a very short period of time, a mere hundred years out of the two centuries covered by the *humanistica;* and that it examines only one very particular facet of a particular style of handwriting: the printed writing-books of the Renaissance, mainly Italian and Spanish. But then it must, of course, be said that "the style of writing which developed into the type fonts in use today certainly is one of special importance and interest to us" (B.L. Ullman).

This is a subject worth discussing at some length in *Visible Language* for all three reasons suggested by Osley: to propose the study of italic handwriting as an effective solution to the problems of teaching (or self-teaching) handwriting to-day; to admit a wider public to the writing-books of the Renaissance; to provide a useful source book for the history of Renaissance handwriting. It should be pointed out that *Visible Language,* as a matter of course, wishes to admit a wider public to the study of writing not only of italic but of *all* letterforms past, present, and future; and wishes to encourage more studies and source books such as this one to be written about written matter generally. Because that is its very raison d'être.

Osley is not only a leading expert in his chosen field of interest, he is also well known as the editor of *The Journal of the Society for Italic Handwriting.* He is naturally very much involved in the so-called Italic Handwriting Movement, although he never mentions it as such in *Scribes and Sources* (except as a reference in two footnotes). In his preface, however, he points to the fact that the manuals of the Renaissance writing-masters "fallen into disuse for over 300 years, began to exercise their magic again in England in the 1880s." He also cites Oscar Wilde as reporting the famous lecture given by Emery Walker in 1888, in the course of which "a photographic projection of a page of Arrighi was greeted with a spontaneous round of applause from the large and attentive audience." He goes on to remind us that it is nearly a century ago that William Morris started experimenting with cursive handwritings of the Italian Renaissance, and was soon followed by Monica Bridges, wife of the poet, as well as by Edward Johnston. Osley further registers that it is now just over half a century "since a young Admiralty clerk

named Alfred Fairbank found civil service handwriting pretty dull and decided that the models of Tagliente and Lucas could be amalgamated in a simple modern hand which would meet all contemporary needs." Osley seems oblivious of the fact that during the twenties Stanley Morison was publishing *The Fleuron,* a major contribution to the study of calligraphy and paleography as well as typography, which compares rather favourably with the round of applause as reported by the author of *The Decay of Lying.* As recently as 1960, B.L. Ullman in his preface to *The Origin and Development of Humanistic Script* stated that: "Stanley Morison's has been the leading treatment in recent years, though I must disagree with him in some fundamental respects."

All this, of course, does not suffice as the briefest account of the so-called Movement. Nor is this the occasion to give a full account. As an indication of the possible scope of such a notion as Italic Handwriting Movement, let it be recalled that according to Ullman, Poggio Bracciolini cannot be ignored as the one who invented the humanistic script and "started the movement" at the beginning of the fifteenth century. In his first chapter Osley suggests that the origins of the italic or chancery hand go back to Carolingian times and to Charlemagne in person. Both are right in their context and in accordance with the views they take.

Not last and not least, America made a contribution of its own to the restoration of calligraphy, starting with E.F. Detterer (a pupil of E. Johnston), R.F. Da Boll, Frances Moore, and continuing with Paul Standard, Arnold Bank, Lloyd Reynolds, and many more. Then in the late fifties and during the sixties, on both continents, there also was a sudden flowering of scholarly books on humanistic scripts with James Wardrop, B.L. Ullman, Berthold Wolpe, Ray Nash, and Osley as the leading experts. Seemingly as a culmination of it all, we are now witnessing an unprecedented calligraphic revival all over the Western World (at the very least in the English speaking cultures), particularly in the United States.

As author of *Calligraphy and Palaeography* (1965), *Mercator* (1969), *Luminario* (1972), and now *Scribes and Sources* (1980), Osley is indeed confirmed as a leading expert in his chosen subject. As editor of *The Journal of the Society for Italic Handwriting* he is also one of the most serious cases on record of what Humphrey Lyttleton variously describes as Johnston's Disease, Cockerell's Complaint, or Italic Fever (Summer 1978, p. 25). In the same capacity he can afford to quote, approvingly (Autumn 1979, p. 100), *The Baltimore Evening Sun* of 1 July 1957: "The center of the movement is England where it has reached the proportions of a cult";

or he can get away with finding fault even with Arrighi (Blessed Be His Name) and his models in the *Operina* (ibid., p. 32). Admittedly, any expert can be described adversely as a cultist, a devotee; or favourably, as a champion. The book under review will make Osley appear even more of whichever one chooses to call him. In any case, he clearly has made a major contribution to the history of his subject.

Scribes and Sources provides a good deal of the information needed to discuss its subject dispassionately — not necessarily in the acrimonious way characteristic of writing-masters in the past. Only a virtuoso of the quill, the pen-knife, and calligraphy could make profitable comments on the "quite significant variations" among Tagliente, Arrighi, Palatino, Mercator, Hondius, Brun, Yciar, Augustinus da Siena, Lucas, Madariaga, and de la Cuesta. "This is a reference book. It is not supposed to be read through at a sitting," warns Osley. This is certainly true for the instructions, alias translations. But the historical, biographical, and technical commentaries which introduce each of the eighteen several chapters are truly absorbing.

Renaissance Italy was a violent period on any account. The schoolmasters and writing-masters, we are told, were no less violent than the rest. When a dozen of them met for some shop talk, Erasmus regarded it as a success if the assembly had broken up without bloodshed. In spite of such passionate devotion, Osley will never let his readers forget that "It is not to be supposed that all Renaissance handwriting was italic. Far from it. The great mass of commercial and personal correspondence continued to be conducted in one or other of the legal, mercantile or secretary hands derived form gothic script." The readers must also be prepared to read that in spite of the immense toil and expense of time and capital which went into the publication of these printed writing-books, both the *cancellaresca* and the *mercantesca* were rapidly becoming obsolete by mid-century. Giovan Francesco Cresci, a gentleman writing-master "delivered a mortal blow to the classic chancery italic — and demolished Tagliente, Vicento, and Palatino — with the publication of his *Essemplare* in 1560." This is only one more "bloody" hyperbole. The real and quite understandable reason was simply "that the pace of business was accelerating and that secretaries were under unprecedented pressure." This is precisely why computers have eventually taken over. And this is what Osley hates: "this mindless hustle, this surrender to the market place."

In both translations and commentaries Osley has the opportunity to describe most, if not all, the educational methods and gadgets which the writing-masters have devised. Yet slate, chalk, and blackboard are never mentioned by the writing-masters. And Osley makes only one passing reference to what have been traditionally part and parcel of the teaching environment. This absence is all the more remarkable since the use of slate and blackboard is documented as early as the Gallo-Roman period. This is not just a question of archaeology. The question is: what is most important — the method? the model? the teacher? the tools? the gadgetry? the demonstration? simply expediency? or what's in the mind? And do we have to decide once for all that whatever the initial teacher, model, or tool, sooner or later we will have to take it upon ourselves to reform our handwriting, "to be reborn"? After all, even in 1565 the Spanish writing-master Pedro Madariago wrote: "At present each writer goes his own way: there is no more agreement between them than between doctors over a doubtful diagnosis. Often the same master will instruct his pupils in different ways, and even worse, teach the same pupil different methods." This problem has not been entirely solved in the twentieth century, is Osley's cool remark.

A puzzling feature of Renaissance writing-books is that they display typefaces as models for handwriting exercises without bothering to give any guidance. This is all the more surprising considering that these copy-books were intended explicitly as self-help for children and adults alike, for beginners as well as for professional scribes. Osley suggests that this serves little purpose and that the reason type was used was *probably* in order to get the book into print more quickly. This hypothesis is less than wholly convincing. It is even improbable for two reasons. The first is that typographic copy-books were not at all exceptional; they were a current product — at least in the Netherlands (where they have been studied by La Fontaine-Verwey). The second is to be found repeatedly in the original texts of the writing-masters and in Osley's commentaries: the writing masters quite explicitly refer students of handwriting to the printers and to typefaces as models to be copied. Thus Yciar (1550): "It is a good thing to copy the type cast by good printers" — to cite only one of several similar remarks here translated from Yciar. In any case, few people today seem to use printed matter, books, or newspapers to study or to practice handwriting.

Osley gives no serious reason to challenge the accuracy of his translations. At least to a foreigner they sound clear enough, whatever the clumsiness of the originals. The main remark which should be made is made by Osley himself when he reflects that "The writing master's task

of explaining his art to his readers was complicated by the absence of an accepted set of technical terms. As a result, although the general sense of a passage is for the most part plain enough, details are sometimes obscure." This small inconvenience was and is compensated by the figures, the woodcuts. These too are in many ways "translations." To reproduce a given model is to translate it in any number of media and materials to meet different needs or moods. Writing-masters have never been concerned with moods. They used any available method, capital, and talent to get into business and stay there. This was not easy but easily quite expensive. Hence the acrimony. The absence of an accepted set of technical terms has never hindered the business of writing — handwriting or otherwise. Such a set is still missing today — maybe less in English than in other languages (?). In any case, writing-masters were not addressing archaeologists, aesthetes, or even artists, but prospective pupils, scribes, notaries, and patronage — all of which call for wholly different attitudes and aptitudes. Ideas, words, and visible symbols generally go their several ways: their concurrence is a rare occurrence; whether it is intentional or not is in most cases hard to say. Surely that is why nomenclature to describe letterforms is a much more complicated issue. Palaeographers and codicologists are struggling with it all the time. Their problems are not to be solved once for all, here and now.

Again, designing letterforms and describing letterforms prove to be two separate issues, even while they are not mutually exclusive. All this was and still is a daily experience, as can be made clear by another passage from Yciar (one which Osley had no particular reason to translate, be it said): "The Gothic letter, which is appropriately called Latin or Roman, was much used in Rome, as can still be seen today in the remains and ruins of ancient buildings." Thus, in 1550, the same letterform was described indifferently as Gothic *and* Roman by a competent writing-master. The chancery fares no better: "I have observed with some curiosity that in the works of Vicentino, Tagliente, and Palatino there are some foreign letters such as Mercantile, Roman, Venetian, Florentine, and Neapolitan, and other kinds which differ in no way except in some flourishes or in respect of their large or small size. In my opinion all these may be compared with *only one round and one cursive hand* [our italics] called Aragonese". Thus wrote Yciar, 1550. The French, of course, took the same view, i.e., the nationalistic one. People such as Plantin, Hamon, Estienne, and Grévin, of course, knew what they were talking about when they discussed the current handwriting of their day, the *écriture courante* or *loopende schrift* (see ch. XVI, *Scribes*). Today we call it *gothic cursive* or *secretary*. To Robert Granjon, another

contemporary Frenchman, it was the *écriture françoyse.* It was so popular that Granjon cut the punches for a typographic version and first used it for schoolbooks, hoping that it would become a bestseller as the national French typeface par excellence, and as distinct from any other style as the Greek or Hebrew characters are distinct from roman or italic. That was in 1558, nearly sixty years after the successful introduction of the aldine italic on the international typographic market. Granjon was followed in his day by A. Tavernier, H. van den Keere, Ph. Danfrie, and lesser punchcutters. All their hopes were disappointed. The result is known as Civilité type. The subject has been studied by H. Carter, H.D.L. Vervliet, La Fontaine-Verwey, and Croisset van Uchelen. Civilité eventually became associated in the minds of the people with Protestantism or the Reformation. By the end of the nineteenth century another Frenchman, J.K. Huysmans, described his des Esseintes, a fellow aesthete of Dorian Gray, as having a copy of *Les Diaboliques* privately printed with Civilité because to his mind their spiky, barbed, and bristling curlicues were absolutely congenial with the sadistic masterpiece of Jules Barbey d'Aurevilly. What's the point of such an amount of history, archaeology, philology, typology? The point is that even the writing-masters and their copy-books cannot give all the answers to all the questions which this subject deserves to raise. Other sources must be tapped.

A direct, graphic illustration of the cultural distribution of the main handwriting styles in Renaissance Italy — namely, the *littera antica (cancellaresca* or *humanistica)* and the *littera moderna* (or *mercantesca)* — is to be found in contemporary documents such as the *Libretto di Maddalena (Scrittura e Civilta,* 2. 1978, pp. 162-208, pl. XII). Maddalena was a Roman *pizzicarola* (porkbutcher), and her "libretto di conto" was an account-book where her customers registered their debts from 1523 to 1537. Out of 102 specimens of individual handwritings, only twenty-one can be identified as reflecting some remote *antica* model; only eight can be said to achieve a good level of fluency in a pure antique style, i.e., italic or chancery. The rest are scribbled in a variety of *mercantesca* (literally: commercial).

Conversely, if one consults the earliest records of the books which were loaned out by the Biblioteca Apostolica Vaticana, 1475-1547, one will find that almost all of the 400 specimens of individual handwritings are in Latin and in *lettera antica;* thirty are in "volgare," of which only seven are in *mercantesca.*

It is at least worth mentioning that the French, too, have leading experts in chancery handwriting. One is Hélène Michaud. She has published (PUF 1967) the thesis she wrote for the Ecole des Chartes: *La*

Grande Chancellerie et les écritures royales au seizième siècle, 1515-1589. Her approach is so different that no writing-master is mentioned in the 700 or so entries which make up the index (pp. 405-16). The handwriting is only briefly described (p. 208) as "perfectly legible in all cases." The rest is all in the following (p. 210): "The Royal Chancery never adopted the so-called humanistic or italic although it was currently used by the secretaries for personal matter, while the handwriting in the acts, perfectly regular, legible and exact, though evolving with the passage of time always remained in the gothic tradition."

Another French expert is Emmanuel Poulle. His subject is *Paléographie des écritures cursives en France du XVe au XVIIe siécle* (Droz, 1966)—more particularly the "gothic" cursive as it was written at the end of the Middle Ages and at the beginning of modern times in Parisian courts of law. Not surprisingly, the XXX plates show satanic scrawls even more sadistic and much less legible by far than the Civilité which des Esseintes pressed into service. According to Poulle, an Italian influence was noticeable. But the main influence was pressure of work. Predictably. Here we find that the origin of the so-called "gothic" cursive is in the royal French chancery by the end of the thirteenth century. Alain de Bouärd (1929) conveniently described it as "mixte" because it was a mixture of book-letter and *epistolaris* (casual handwriting). Whatever the name, this style persisted in France until the middle of the seventeenth century.

From these sources we could take the merest glimpse of what Osley means when he admits that it should not be supposed that all Renaissance handwriting was italic. It is even possible to realise that it is indeed very far from being the case. As with all the other books by the same expert author, this one is a fantastic piece of learned propaganda for one particular handwriting style. This is in keeping with a very long tradition indeed. Osley is fully entitled to do so, needless to say, and gratefully invited to persevere. Yet, since no decent reviewer can hope to match the sources and resources of this particular champion (let alone the Home Forces, the Légions Etrangères of the Italic Handwriting Movement, and the acrimonious prose and ghosts of a majority of Italian writing masters), this reviewer wishes to make a few comments on the study of handwriting and calligraphy today and in the near future.

First, even from *Scribes and Sources* (i.e., from the Renaissance writing-masters) we must learn to make a clear distinction between *handwriting* and *calligraphy*—not at all an easy distinction to make! It is precisely one of those things which Osley, with yet another warlike

hyperbole, calls a "minefield," i.e., a ground where even Greek palaeographers such as B. Atsalos tread only with the utmost caution. To quote a French expert, M.R. Marichal: "La difficulté est de savoir ce qu'il faut savoir voir" (The difficulty is to know what to look for). Indeed. But it may be more helpful to quote P. Hamon (1567, *Scribes*, p. 223): "No sort of writing is good or profitable except in so far as it enables us to conduct the affairs of everyday life more effectively . . . . What is the style which is most used? The cursive secretary hand that we employ for everyday purposes." The point here is not that *commune courante* is translated as *cursive secretary* and that the Italian chancery or Italian cursive secretary did not come to that French mind; the point is that service, utility, expediency, speed, pressure of business take precedence over and above any other consideration. Overwhelmingly so, then as now.

"We are *sometimes compelled* [our italics] to draw with our pens rather than to write" (ibid.). That is probably what today we could all agree to call calligraphy — except that today no one is any longer *ever compelled* to draw letterforms rather than to write them, except type designers. In fact, the situation is altogether so different today — not simpler by any means — in any and every respect that casual handwriting has become even more of a problem than calligraphy. *Visible Language* has devoted several special issues to the teaching of handwriting. This reviewer has already expressed some views about fundamental aspects other than aesthetic or cosmetic (which are NOT at all negligible, needless to say). Therefore it may be permissible to conclude with the hope that Osley and the Italic Militia will forgive us when we seem to recall that the "italic" may well be the best introduction to the use of a broad nib, but that no writing-master, Italian or otherwise, ever suggested that one style was enough "per satisfare agli varii appititi degli homini" (To provide for the various needs of the people) (Tagliente).

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General Information

Visible Language is concerned with research and ideas that help define the unique role and properties of written language. It is a basic premise of the Journal that writing/reading form a distinct system of language expression which must be defined and developed on its own terms. Published quarterly since 1967, *Visible Language* has no formal organizational affiliation. All communications should be addressed to

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