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5. Telefunken-Schnelldrucker with printing part made by the Anelex Corporation, in use in the Computing Center at the University of Hamburg.
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7. M. Reed and E. Osswald, *My First Golden Dictionary* (New York: Golden Press, 1963).
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15. *Ibid.*
16. Bemmer, *op. cit.*

A Proposed Fontstyle for the Graphic Representation of the Oh and Zero

Allen G. Vartabedian

A new fontstyle is proposed for the machine rendering of the graphic representation of the letter oh and the number zero. It prescribes placing a loop on the oh and drawing the zero as an oval. The new convention is intended for use in communication environments where the discriminability of graphic symbols is critical. These environments include use of devices such as teleprinters, computer line printers, keypunch machines, and cathode ray tube displays. The proposed new fontstyle does not draw upon previous conventions for distinguishing between these symbols and consequently avoids a current conflict in slashing either the oh or zero. A design criterion is also presented for distinguishing between the numbers and letters of a given font.

I. Introduction

In recent years the question of whether to slash the oh (alpha O) or the zero (numeric 0) in the machine rendering of the graphical representation of these symbols has been bandied about without resolution.¹ Proposed standards have oscillated between slashing the oh and slashing the zero with little agreement between the proponents of either of the two camps.

Historically the data communication community has adopted the convention of slashing the zero.² They reasoned that in teletypewriter environments the frequency of occurrence of zero is less than oh, and consequently the embellished character would appear least often with this convention. Moreover, numerics generally occur in a strictly defined format, and therefore an operator would be cued to expect the novel character and would not find it annoying.

More recently, the computer community has generally adopted the convention of slashing the oh based on the frequency of occurrence argument.³ As long as these two communities remained independent of each other there was little problem with the existence of these two conflicting conventions. However, when

programmers, analysts, teletypewriter operators, and code clerks began transferring between the activities in the communications and computing environments, the need for a single standard became apparent.

In environments where graphic symbol recognition is critical, characters should be highly legible. A critical environment is one in which the cost or likelihood of an error is great. Computer and communication operations generally provide such a critical environment.

In this paper, legibility is understood to mean that attribute of a graphic symbol which allows it to be identified to the exclusion of all other symbols in a defined set. In addition, speed of identification is a factor contributing to legibility.

Using this definition for legibility, it is seen that each symbol of a defined graphic set must be unique in fontstyle. Furthermore, the fontstyle should admit to rapid identification or identification under conditions where the display medium is severely degraded (e.g., symbols which subtend a small visual angle, symbols of low brightness or brightness contrast, short exposure time, or degraded by "noise"). Symbols drawn with a matrix of light points can be considered to be of reduced resolution.

II. Results of First Legibility Experiment

An experiment testing the legibility of a set of upper-case, lower-case, and numeric symbols was conducted to determine the pattern of intersymbol confusions. Eight subjects with 20/20 visual acuity uncorrected in the near and far field were shown symbols for a period of approximately one millisecond. Symbol height subtended an arc of 20 minutes at the subject's eye. Symbols were shown using a 7×9 dot matrix on a cathode ray tube at three brightness levels. In this test the zero was defined as a round symbol with a virgule through it and the oh was defined as an oval symbol as in Figure 1. The confusion matrix for the oh and zero for each brightness level is presented in Table I.

Looking at the oh and zero alone, the predominant confusion pattern was that, in total, the zero was called an oh 11 times whereas the oh was called a zero only once. These differences in error rates are significant according to a Poisson test at the 1% level.⁴

TABLE I. Confusion Matrix for Oh and Zero for First Legibility Experiment (8 Subjects)

Symbol Shown	Response		Brightness (Ft-Lamberts)
	Zero	Oh	
Zero		3	5
Oh	1		
Zero		5	8
Oh	0		
Zero		3	11
Oh	0		
SUMMARY			
Zero		11	
Oh	1		

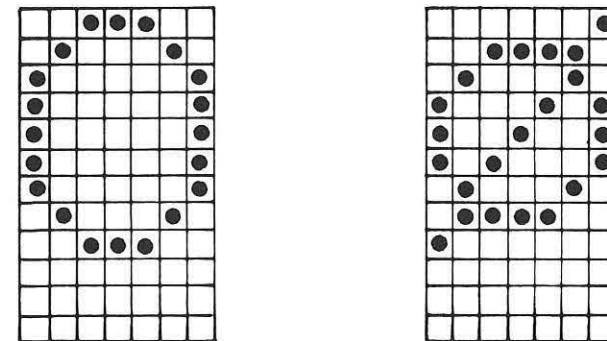


Figure 1. Oh (left) and zero used in first legibility experiment.

The above pattern of confusion of the oh and zero is seen to be one in which the given symbol is mistaken for another symbol with a simpler outline more often than the reverse. Deuth⁵ found this same result. Consequently, the simpler symbol should be the one which is more likely to be confused. Conceivably, the oh is less likely to be confused because of visual cues provided by the constructive redundancy of letters in written languages. This suggests that the simpler symbol should be the zero.

III. Criteria

The predominant criterion in the past for the fontstyle for the oh and zero has been to embellish that character which has the lowest frequency of occurrence in the given communication environment. When such a frequency cannot be defined, this definition is unusable. Furthermore, even if such a frequency could be defined, it would not necessarily lead to a valid criterion for distinguishing between oh and zero. Using the concept of "figural goodness" (a measure of the enhancement of the perceptual process of decoding visual stimuli) from Gestalt perception theory, the apprehension of meaning from a given symbol can be facilitated by the shape of the symbol.⁶ Consequently, other criteria for the fontstyle of alphanumeric symbols suggest themselves.

Fontstylists have created a vast number of fonts for variety and esthetics in typographical composition. These fonts in many cases are greatly differentiated from each other by means of basic shapes, added stylistic elements, or the use of ornamentation such as serifs. The great variety in fontstyles has for the most part manifested itself in the alphabetic symbols alone. The numeric symbols have been designed within very narrow limits of graphical freedom. Table II indicates how narrow these limits are—tracing the numerics from the third century B.C. to the fifteenth century.

As a result of the great variety of fontstyles, readers are able to contend quite effectively with the many different graphical representations of alphabetic symbols, even when such graphics are entirely novel. The fact that written languages are highly redundant makes this task quite easy. The visual cues provided by redundancy reduce the stringency of the need for the unique identifiability of symbols since the meaning can be guessed (visually synthesized) from context.

TABLE II. *Hindu-Arabic Numerals*

	1	2	3	4	5	6	7	8	9	0
Nānā Ghat	—	=	≡	¥		φ	7		2	
India 3rd century B.C.										
Devanāgarī	१	२	३	४	५		७	८	९	०
India 10th century										
Ghobār	1	2	3	4	5	6	7	8	9	0
Spain c.976										
Italy c.1400	1	2	3	4	5	6	7	8	9	0

No similar cues are available in the use of numerics where readers encounter graphic shapes that are mapped within much narrower confines.

A proposed criterion for the discriminability between the oh and zero then would be one that states that numerics should be relatively unembellished conforming as nearly as possible to traditional forms based on their Hindu-Arabic antecedents, while any distinguishing marks should be placed on the alphabetic.

This criterion simply states that if any symbol is to be marked, then it should be an alphabetic rather than a numeric. There are situations where such marking is unnecessary, either because discriminability is not critical or meaning can be derived from format or context. Here shape can be used as the distinguishing characteristic between the oh and zero. In fact, from the standpoint of good typographic design it is desirable to shape the zero oval (as traditionally drawn) and the oh round [see preceding article by Dirk Wendt].⁷ In situations where the symbol is clearly defined by format or context these characteristics are fully adequate. However, where such format and contextual cues are unavailable and the need for discriminability is critical, graphic markings on the oh are necessary.

IV. Proposal

As indicated above, the proposed convention should be one which prescribes marking the oh and leaving the zero unembellished. The presently used convention of placing a virgule through the oh is consistent with this criterion. However, it is in direct conflict with another existing convention of slashing the zero.

The proposed convention prescribes a loop at the top of the oh and an oval form for the zero. Figure 2 presents the proposed oh paired with its corresponding zero. It is seen that this pair of symbols results from the above criterion and that both symbols have high values of "figural goodness." Those qualities contributing to "figural goodness" include continuity, simplicity, unity, and the lack of apparently superposed forms.⁸ These symbols satisfy the requirement for the unique discriminability between the oh and zero.

This fontstyle has the following desirable properties:

1. It avoids the conflict of using a virgule on either the oh or zero.
2. The appearance of the oh is not fundamentally altered from that of a O as in the case of Ø.

TABLE III. Confusion Matrix for Oh and Zero for Second Legibility Experiment (12 Subjects)

Symbol Shown	Response		Brightness (Ft-Lamberts)
	Zero	Oh	
Zero		3	5
Oh	0		
Zero		0	8
Oh	0		
Zero		2	11
Oh	3		
SUMMARY			
Zero		5	
Oh	3		

3. This is a familiar representation of script oh. It is, in fact, similar to handwriting standards in several countries.
4. It does not violate the appearance of the numerics which are part of an international graphic set.
5. It does not violate certain European, Latin based, alphabets in which Ø and O are valid alphabetic symbols.

Figures 3, 4, and 5 show that this convention for the oh and zero can be implemented under conditions of reduced resolution on a cathode ray tube. Figure 3 presents this pair with a 7 × 9 matrix of light points, Figure 4 with a 5 × 7 matrix, Figure 5 with strokes, and Figure 6 on a teletypewriter.

V. Results of Second Legibility Experiment

A second legibility experiment was conducted to test the proposed oh and zero as presented in Figure 7. The design of this experiment was identical to the first experiment except that twelve subjects were used.

The confusion matrix (Table III) shows that, in total, the zero was called oh five times and the oh was called zero three times. Using a Poisson test,⁹ it was found that these error rates are not significantly

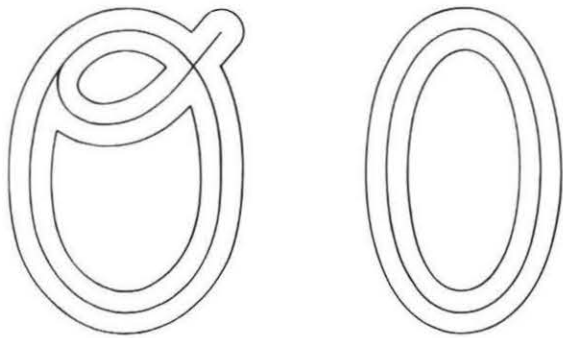


Figure 2. Proposed oh (left) and zero.

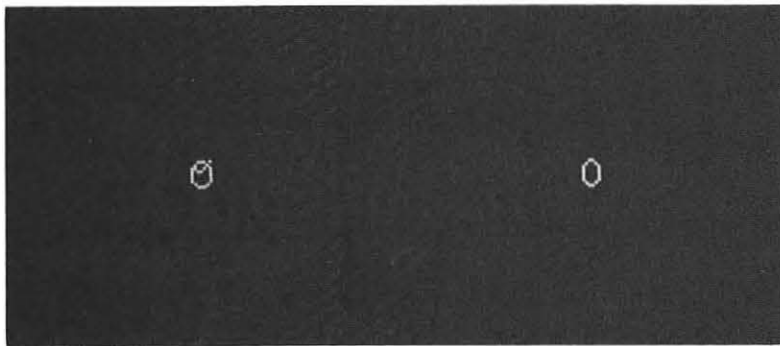


Figure 3. Proposed oh and zero in a 7×9 matrix displayed on a cathode ray tube.

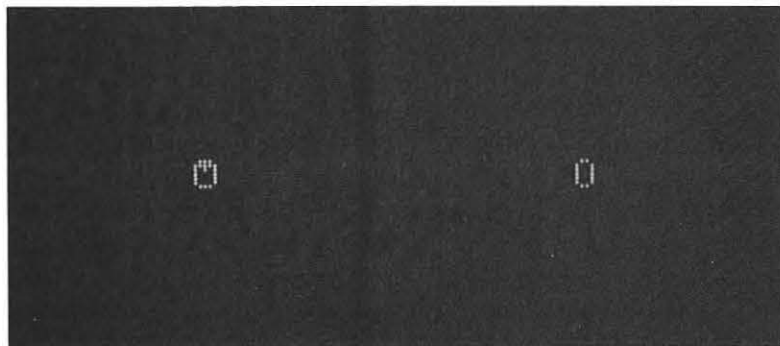


Figure 4. Proposed oh and zero in a 5×7 matrix displayed on a cathode ray tube.
256

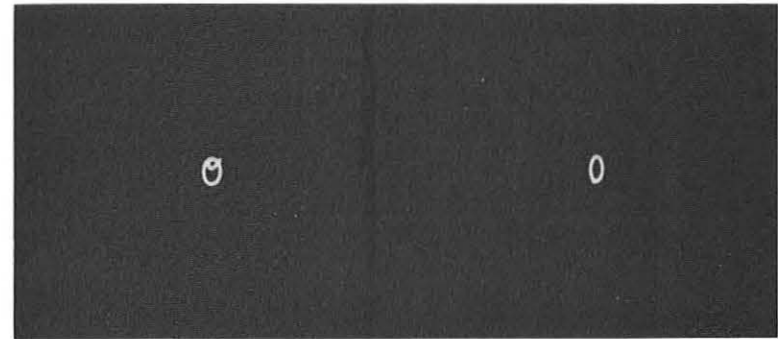


Figure 5. Proposed oh and zero drawn with strokes on a cathode ray tube.



Figure 6. Proposed oh and zero produced with a teletypewriter.

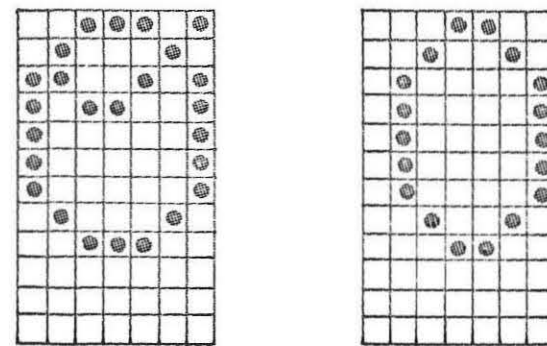


Figure 7. Oh and zero used in second legibility experiment.
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different. Moreover, the combined error rate for the proposed oh and zero is less than half that for the prior oh and zero. We can conclude from these results that a more legible pair of symbols has been achieved with the proposed oh and zero.

VI. *Recommendation*

It is recommended that the convention for distinguishing between the oh and zero in environments where the legibility of symbols is critical be that the zero is narrow and unmarked and the oh has a loop at the top as in Figure 2. This convention has the desirable properties of avoiding the conflict of slashing either the oh or zero, of representing the oh in a familiar form, and of representing the oh without fundamentally altering its appearance.

1. For a sampling of opinion on this subject, see R. W. Bemer, "Towards Standards for Handwritten Zero and Oh," *Communications of the ACM*, VIII (August 1967), 513-518.
2. Revised Appendix D, X3.6.5.4. *Working Group Report* (New York: USA Standards Institute, 3 March 1967).
3. *Ibid.*
4. E. S. Pearson and H. O. Hartley, *Biometrical Tables for Statisticians*, I (Cambridge: University Press, 1958), 185.
5. A. F. Deuth, *Final Engineering Report on Informax*, No. 1176-FR-10 (New York: Hogan Labs., 30 November 1953), p. 22.
6. R. S. Easterby, "Perceptual Organization in Static Displays for Man/Machine Systems," *Ergonomics*, X (February 1967).
7. Dirk Wendt, "O or O?," *Journal of Typographic Research*, III (July 1969), 241-248.
8. Easterby, *op. cit.*
9. Pearson and Hartley, *op. cit.*

The Use of Type Damage as Evidence in Bibliographical Description

G. Thomas Tanselle

Accidental variations in the typography of books can furnish important clues about the regular processes of printing—both in compositorial analysis and in the classification and ordering of successive printings, issue, and states. The article considers the question: what degree of physical detail should be recorded in a descriptive bibliography? Examples of type-damage discovered in a collation of Herman Melville's works are illustrated.

It is an axiom of analysis in any field that accidental and unplanned features of the object under analysis may form the basis for useful analytical techniques. Bibliographers recognized early that accidental variations in books could furnish important clues about the regular processes of printing, and they saw that the aspect of the book most subject to such unplanned deviations is its typography—for there are thousands of type-impressions on every page which can vary as a result of improper inking, normal type wear, or type damage produced by careless handling. Examination of these irregularities may be helpful in different ways for books of different periods—in compositorial analysis of seventeenth-century books, for example, or in the classification and ordering of successive printings of later books. This kind of investigation has been employed so widely that many persons outside the field of bibliography have heard of it, and bibliographers are sometimes referred to, amusedly if not condescendingly, as people who study "broken types."

When an activity comes to symbolize, in the popular mind, a more complex process of which it is only a part, the result is often its misuse or abuse by those who do not understand (because they have never been introduced to) the larger process. For obvious reasons this situation has been particularly noticeable in the case of nineteenth- and twentieth-century books: by this period technological improve-