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Phonological and Orthographic Relationships to Reading Performance

Robert A. Barganz

This study investigated the use of an intermediate level of orthographic representation based upon the theoretical framework of transformational-generative grammar. A general objective was to determine whether a system of semantic correspondence was utilized when irrelevant phonetic aspects of orthography were encountered by good and poor readers from a fifth-grade population. A $2 \times 2 \times 4$ factorial design was employed to investigate the effects of reading ability (good and poor), word reality (real and pseudo), and mode of presentation for stimuli and response items (oral and written). Good readers performed better than poor readers at a statistically significant level ($p < .0005$) on those tasks which required recognizing regularities on a deep level. When regularities were recognized on a surface level, these differences between good and poor readers diminished. Good readers appeared to display a search technique which abandons a simpler level of correspondence in favor of one more efficient, one which precludes grapheme/phoneme correspondences for one directed toward semantic correspondence.

The purpose of this study was to investigate the abilities of good and poor readers to recognize the form of derived words where morphophonemic alternation occurs but orthographic constancy exists. Recent models of linguistic (Chomsky and Halle, 1968; Venezky, 1970b) and reading (MacDonald, 1969) competence point to regular phonological rules which are reflected in the tasks. Normative performance data which may reflect the developmental acquisition of such competence is nonexistent. It is with this exploratory aspect in mind that this study was undertaken.

The standpoint that the reading process may be described in direct letter-to-sound terms seems unfeasible. American descriptivists such as Bloomfield (1961) and Fries (1963) recognized the unphonemic elements of English orthography and considered them deviations to be taught last. This concern for the degree of letter-to-sound match has characterized the question of the regularity of the English spelling system. Recent evidence suggests that phonic generalizations may

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not adequately equip students for their encounters with English words (Bailey, 1967; Burmeister, 1968; Clymer, 1963; Emans, 1967). Current descriptions of the relationship between conventional English orthography and the sound system of the language lend support to the belief that the orthographic system employed in English is far more regular than previously thought. In fact, it may be considered a near optimal system for native speakers of English (C. Chomsky, 1970; N. Chomsky, 1970). As Venezky (1970a) and Chomsky and Halle (1968) have shown, a direct letter-to-sound relationship description, though simpler, is a less adequate method linguistically. The system is not based on such a univariate foundation alone. Rather, it corresponds to a more abstract level of representation. Venezky (1967) states, "Spelling units are not related directly to sound, but to an intermediate (morphophonemic) level first, and then to sound [p. 84]." Evidence for the support of abstract rules on psychologically valid grounds has been reported by Ainsfeld (1969).

According to phonological theory within the framework of transformational grammar, in the lexical level of representation of a word many phonetic features of spoken language are suppressed. Although phonetic variations are considerable, they are automatic in the phonological system of the language. Conventional orthography, on the other hand, ignores them and by corresponding to lexical spelling rather than phonetic representation, "permits immediate direct identification of the lexical item in question, without requiring the reader to abstract away from irrelevant phonetic detail [C. Chomsky, 1970, p. 291]."

An orthography which corresponds directly in letter-to-sound terms represents the phonetic features of a lexicon, such as exhibited in the International Phonetic Alphabet. With this system the graphic depiction of spoken language is attempted; the items "mortal" and "mortality" are represented as/ ˈmɔrtl̩/and/mɔrˈtælətɪ/. The pair of words, because of the vowel alternation, receives two different spellings and each member of the pair constitutes a separate lexical item. Conventional orthography, however, indicates the semantic relationship between pair members by disregarding the automatic pronunciation shift and by presenting the members as variant forms of the same word. This maintenance of semantic correspondence

(or morpheme identity) reveals a regularity between semantically related items which a phonetic orthography disregards. The pair of items "mortal" and "mortality" are preserved in conventional orthography as semantically related lexical entities, although phonological changes are apparent. By this system, then, a higher order of regularity may be observed than by a direct letter-to-sound representation method.

Briefly, orthographic representation is not bound to phonemic description alone (Francis, 1958). A more complex level of generalization is inherent in the system as it exists, the function of which is to provide a means of semantic transmission rather than one of only phonological transmission (Vachek, 1966). A knowledge of this higher order system should enable skilled readers to process words perhaps as larger graphemic units rather than as units to be broken into phonological components to be matched with oral counterparts.

It is suggested, therefore, that "what the mature reader seeks and recognizes when he reads is not what are commonly called grapheme/phoneme correspondences, but rather the correspondence of a written symbol to the abstract lexical spelling of words [C. Chomsky, 1970, p. 296]." "In order to progress to more complex stages of reading, the child must abandon this early hypothesis and come eventually to interpret written symbols as corresponding to more abstract lexical spellings [C. Chomsky, 1970, p. 297]." Thus an indirect relationship of orthography to pronunciation must be learned.

As an illustration, consider the relationship of orthography to spoken language. Phonological variation of lexical items in the language is abundant: across time, across group norms, across social context, and across syntactical and phonological environments. Consistency in orthographic representation operates as somewhat of a common denominator for such variation. Semantic similarity is coded through spelling. The item "iron" will be expressed consistently despite the phonological variants /ˈaɪn/ and /ˈɑrn/. Likewise, where phonological change occurs due to suffix addition, semantic similarity is maintained as in the pair /dɪ ˈfaɪn/ and dɛfa ˈnɪšən/, "define" and "definition."

The relationship of phonological processing ability to reading ability is unclear. A study done by Robinson (1967) on the develop-

mental pronunciation of suffixed words indicates that the system seems, indeed, to be one not fully internalized by the time the children may need it for reading. The four age levels tested were grades three, six, nine, and adult. Subjects were asked to form suffixed words from theme words and theme words from suffixed words. Ability was measured in terms of stress placement and vowel and consonant values. The tasks, then, required encoding by the subjects after they read the stimulus sentence. Results indicated that there were fairly regular developmental progressions in the abilities measured and performance was significantly better on real words than on pseudo words.

Theoreticians have proposed that at least in the formative stages of reading, a process of inner speech occurs. Carroll (1969) states, "Silent reading of a printed message involves decoding the message into some form of covert spoken behavior or 'inner speech,' and that in turn, if the message is to be understood, doubtless depends on an underlying competence in the grammatical and semantic rules of the language [p. 6]." According to the Goodman (1968) schema this conversion into an inner speech is classified as a "recoding" stage; the term "decoding" is reserved for a subsequent stage whereby meaning is acquired.

While the degree to which inner speech is present in suffixed words has not been researched, the phenomenon of subvocalization in reading has been demonstrated. Edfeldt's (1959) study shows an increase in subvocalization, as measured by electromyographic methods, as reading material becomes more difficult. In light of C. Chomsky's (1970) comments, the question remains unanswered as to whether processing written words with inner speech represents an early stage of reading which may be reverted to. The suggestion exists that different stages of reading may be employed by the individual as the difficulty of the material varies for him.

Existing research on the distinctions between good and poor readers has been primarily of a descriptive-correlational nature. Langman (1960) suggests that what poor readers lack in learning to read is the "ability to direct attention to the significant visual and auditory stimuli in word recognition stiuations [p. 31]." Hence in the case of suffixed words, the good reader may be focusing on the "common item" relationship with the theme word, while the poor

reader is still doggedly attempting to translate or "recode" on the direct grapheme-phoneme basis.

The term "significant stimuli" under such conditions would suggest that the stimuli to be pursued first would be that of a semantic relationship, and second, the grapheme/phoneme correspondence relationship. This followed to its logical conclusion would suggest that the good reader exploits the "morphophonemic" nature of the orthography more than the poor reader does. And concomitantly in doing so, he has focused attention on a semantic relationship which facilitates Goodman's (1968) "decoding" stage.

The good reader, then, may be said to impose the significant structure upon a derived word. Neisser (1967) contends that in word perception the subject constructs what he sees in an act labeled "figural synthesis." "In this sense it is important to think of focal attention as a constructive, synthetic activity rather than as purely analytic. One does not simply examine the input and make a decision; one *builds* an appropriate visual object [Neisser, 1967, p. 94]." This type of cognitive processing, it would seem, may be derived from the subject's set to search for such relationships. Such performance appears somewhat unsurprising in light of the findings of Levin and Watson (1963) that a "set for diversity" is advantageous; that is, if subjects are presented with multiple correspondences early in instruction, in contrast to a one-to-one correspondence as in "linguistic" readers, they will be more likely to develop a useful problem-solving approach to the reading task.

One question pursued in this study was whether conventional English orthography may be considered "optimal" in contrast to a more "phonemic" orthography. To explore this dimension, derivationally formed words were employed where consonant and vowel values regularly change by rule from the theme form to the derived form, e.g., *logic/logician, rise/risen, baron/baronial.* Both real words and pseudo words were used to measure the degree to which the rule systems and cue systems were internalized.

Phonological performance, as measured by a recognition task, was investigated. Questions pursued were the degree to which such performance exists in both real words and pseudo words and the degree to which it discriminates between good and poor readers. It

was investigated in terms of both oral and visual (orthographic) method of presentation and mode of response.

Thus an oral/oral task measured subjects' ability to auditorily recognize the correct form of derivational relationships where consonant and vowel alternation occurs. In such a task the theme form (or root word) of the target word was verbalized within a spoken sentence context: for response, four verbalized alternatives were presented as slot fillers of a spoken sentence used for context. For example, the word "revere" was used in a sentence which was read aloud by the experimenter. After the sentence was read, the word "revere" was said aloud twice by the experimenter. A second sentence containing the word "reverence" was read aloud by the experimenter. The word "reverence" was not said, but the position of it was indicated by the sound of a toy cricket. Four pronunciations of "reverence" were presented on a tape recorder, one item was to be selected as correct.

An oral/visual task measured subjects' ability to relate a changed phonetic form to orthographic representation, a skill of spelling in contrast to reading. Good readers would be expected to perform better on such a task. Furness (1956) found that the correlations between scores on reading tests and scores on spelling tests usually fall in the range of .80 to .85; Otto and McMenemy (1966) and Harris (1970) warn, however, that even though poor readers are rarely good spellers, good readers may be poor spellers. In this task the theme form of the target word was verbalized within a spoken sentence context: for response items, four orthographically depicted items were presented as slot fillers of a spoken sentence used for context. For example, the word "revere" was used in a sentence which was read aloud by the experimenter. After the sentence was read, the word "revere" was said aloud twice by the experimenter. A second sentence was read aloud by the experimenter. The word "reverence" was not said, but the position of it was indicated by the sound of a toy cricket. Four orthographic depictions of "reverence" were presented by an overhead projector; one item was to be selected as correct.

A visual/oral task measured subjects' ability to ascribe the correct changed phonetic form auditorily from a stimulus presented in conventional orthography, as may occur in oral or subvocal reading.

The target word was presented in orthographic form within a spoken sentence context. The response items were presented as in the oral/oral task. For example, the word "revere" was presented by an overhead projector while a sentence, in which the word was used, was read aloud by the experimenter. The position of "revere" in the sentence was indicated by the sound of a toy cricket. A second sentence was read aloud by the experimenter. The word "reverence" was not said, but the position of it was indicated by the sound of a toy cricket. Four pronunciations of "reverence" were presented on a tape recorder; one item was to be selected as correct.

Finally, a visual/visual task measured subjects' ability to recognize a derivational relationship by cues provided by the orthography, a reading skill of bypassing direct spelling-to-sound correspondences to the facilitation of semantic relationships. The target word stimulus was presented in conventional orthography within a spoken sentence context. The response was presented as in the oral/visual task. For example, the word "revere" was presented by an overhead projector while a sentence, in which the word was used, was read aloud by the experimenter. The position of "revere" in the sentence was indicated by the sound of a toy cricket. A second sentence was read aloud by the experimenter. The word "reverence" was not said, but the position of it was indicated by the sound of a toy cricket. Four orthographic depictions of "reverence" were presented by an overhead projector; one item was to be selected as correct.

Nine hypotheses were tested to answer a number of particular questions since the research was considered exploratory in nature. The orthogonal comparisons in hypotheses one through eight were considered overriding concerns in the analysis of the data. Hypothesis nine was tested to help clarify the issue of the optimality of conventional orthography compared to a phonemically mapped one.

It was expected that good readers would perform better than poor readers on the four tasks involving modality variation as C. Chomsky (1970) suggests the ability of the child to interpret the orthography directly at the lexical level should increase naturally as his phonological competence increases. Additionally, on the spelling-like task good readers would be expected to perform better, as well as on the seemingly reading-like tasks.

The work of Robinson (1967) would suggest that performance on

real words would be better than on pseudo words. Knowledge of real words may clearly confound the testing of principles where word samples are used.

Finally, the theoretical constructs of the conventional orthographic system would suggest that such a system, though more complex, is more efficient.

The nine hypotheses which were tested follow:

1. Good readers will perform significantly better than poor readers on (a) the oral/oral task, (b) the oral/visual task, (c) the visual/oral task, and (d) the visual/visual task.

2. Performance on real words will be significantly better than on pseudo words on (a) the oral/oral task, (b) the oral/visual task, (c) the visual/oral task, and (d) the visual/visual task.

3. Subjects will select the correct response reflecting conventional English orthography more frequently than phonemic approximations in the visual/visual task.

Subjects

The sample was provided by eighty fifth graders from four elementary schools in Sun Prairie, Wisconsin. The school population draws from social classes ranging from upper-lower to upper-middle and from both urban and rural settings. Forty good readers and forty poor readers were represented by an equal number of males and females. Subjects were operationally defined as good readers by scores above the fifth stanine on both the word meaning and paragraph meaning subtests of the *Stanford Achievement Test, Intermediate II*; poor readers were operationally defined by occurrence of both scores in the second, third, and fourth stanines.

Method

A 2 × 2 × 4 factorial design was employed to investigate the effects of reading ability (good and poor), word reality (real and pseudo), and modality of stimulus and response (oral/oral, oral/visual, visual/oral, and visual/visual). Five subjects were assigned to each of the 16 cells.

The task of 110 items reflected 22 morphophonemic alternation types. Eight reflected consonant changes: {k–s}, and seven synthesis patterns, {t–č}, {t–š}, {d–ǰ}, {s–š}, {s–ž}, {z–ž}, and {k–š}, as

in *act/action*. Five patterns consisted of vowel alternation, from free alternate (long pronunciation of a vowel) to checked alternate (short pronunciation of a vowel), where major stress patterns did not change: {e–æ}, {i–ɛ}, {ai–I}, {o–ɑ}, and {ju–ʌ}, as in *sane/sanity*. And the remaining nine patterns consisted of vowel alternations dependent upon major stress pattern change. Four of these were due to the loss of stress: {e–ə}, {i–ə}, {ai–ə}, and {æ–ə}, as in *horizon/horizontal*. Five were due to the acquisition of stress: {ə–e}, {ə–i}, {ə–ɑ}, {ə–æ}, and {ə–o}, as in *mortal/mortality*.

The words selected for the tasks reflected alternation rules described by Venezky (1970b). The corpus of words were composed from a sample taken from *Webster's New School and Office Dictionary* (1965). Five individual items from each category were selected. Where several varieties of morphemes were available to serve as suffixes, word samples were placed in "identical morpheme" groups. The number of items were then selected according to the proportional frequency which a morpheme group represented. Hence, if 20 cases of *-ity* and 17 cases of *-ism* were the existing suffixes available, three items were selected from the *-ity* group and two items from the *-ism* group. In cases where several suffix patterns existed, samples were drawn from the five most abundant groups. For those cases not so clear cut, the writer utilized a random method, the words not being seen.

Real words were classified to provide a body of semantically related samples to draw from. Because word-frequency (Savin, 1963) and word length (McGinnies, Comer, & Lacy, 1952) may contribute to difficulty, words were randomly selected from all within groups. Pseudo-words were constructed to reflect the concomitant alternations displayed by real words. The pseudo-words were read for their proximity to real words and for their assigned created meanings by three persons, each representing one of the disciplines of reading, linguistics, and literature. Revisions were made on the basis of suggestions.

The task consisted of two straightforward sentences of a definitional context being read to the subjects. The slot position of the target word in sentence one was indicated by the sound of a toy cricket and subjects were exposed to the theme form either visually or acoustically. The same operation was performed with the second

sentence. Four systematic response choices were provided for the derived forms either by an overhead projector or by magnetic tape. Subjects were instructed to select the alternative which seemed correct. Neisser (1967) suggests such a scanning technique so that the presence of an "after image" does not impose a template effect. His discussion is directed towards visual images, but it is reasonable to expect that the same effect may operate auditorily. Items answered correctly were tabulated for each subject and mean scores for each cell were calculated.

The lexical items which constituted the sentential context for the target words were restricted so that they fell below the purported median free association vocabulary size of fifth graders (Bryan, 1953). Only words falling below this median were utilized by comparison to the Kučera and Francis (1967) word frequency list.

All items for the task were ordered at random. Response choices varied systematically, focusing on those phonemes which alternated. In stress shifting words, the focus of attention was placed on the vowel linearly nearest the added suffix. The order of response alternatives was assigned by random. See Appendix A.

Four measures of internal consistency were computed as a method of determining the reliability of the task. Using a Pearson r for the calculations, the correlations are as follows: real words = .90, pseudowords = .90, good readers = .87, and poor readers = .88.

Results

The analysis of the data was pursued through four major types of tests. Hypotheses 1 through 8 were tested by a planned comparisons technique. This method is suggested (Hays, 1963, Chapter 14), instead of an ordinary analysis of variance and F-test, when one has particular questions to be answered at the onset of an experiment. It is an assurance that comparisons are unrelated and nonredundant.

Hypothesis 9 was tested by a single-sample test involving proportions (Blalock, 1960). This was necessary since the focus of the hypothesis was on the degree to which conventional orthography was utilized in comparison to phonemic approximation spellings.

Following the testing of hypotheses 1 through 8, an F-test for "other comparisons" was made. "If this F-value is significant, then

[those] comparisons of secondary interest can be examined individually by post-hoc methods [Hays, 1963, p. 478]."

Several Scheffé post-hoc comparisons were computed. Following the recommendation of Hays (1963) not all conceivable comparisons were made. Rather, comparisons were made where the writer, upon inspection of the data, suspected large effect to lie.

Hypotheses 1 through 8 were tested by the technique of planned comparisons. Two conditions must be met before these comparisons may be considered independent and nonoverlapping. First, an assumption was made that population distributions were normal. Second, the condition of orthogonality was met. The criterion of orthogonality in planned comparisons assures one that comparisons are statistically independent. The conditions set for achieving orthogonality were met for the 8 comparisons which were made.

The planned comparisons of good readers and poor readers (Hypotheses 1 through 4) indicated that good readers performed significantly better than poor readers on the o/o ($p < .0005$), o/v ($p < .0005$), v/o ($p < .0005$), and v/v ($p < .025$) tasks. It was observed that performance differences on the v/v task did not reach the significance level exhibited in the other three tasks. The results are presented in Table I. The results of the post-hoc investigations help to clarify the interaction which took place and which help to account for this anomaly.

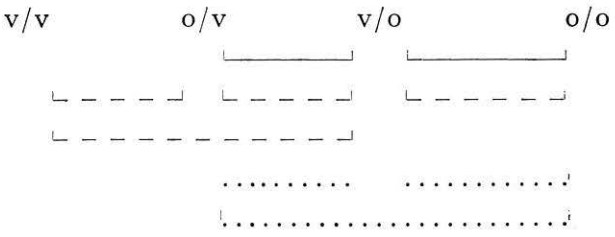
Performance on real words was significantly better than on pseudowords (Hypotheses 5, 6, and 7) in the o/o ($p < .0005$), o/v ($p < .05$), and v/o ($p < .0005$) tasks. Performance on the v/v task was not significantly different ($p > .05$). Results are presented in Table I.

It was shown that the v/v task rewarded the simple recognition of surface structure similarity, whereas the o/o, o/v, and v/o tasks demanded a recognition of deep level correspondence. As the rule which operated did not involve recovery from underlying forms in the v/v task, the comparison of performance with real and pseudowords did not seem affected by knowledge of individual lexical items. That is, knowledge of the grammar system did not seem to be measured by the v/v task and, hence, real word knowledge did not inflate performance scores on real words.

Conventional orthography was used in preference to phonemic representations significantly more often in the visual/visual task.

TABLE I. Summary of Planned Comparisons Tests

Source	*SS*	*df*	*MS*	*F*	*t*	Probability
Between groups	29,711.4	15				
Comparison:						
1. o/o, Gd. > Pr.	1,843.2	1	1,843.2	12.29	3.5060	.0005
2. o/v, Gd. > Pr.	6,808.0	1	6,808.0	45.41	6.7381	.0005
3. v/o, Gd. > Pr.	3,175.2	1	3,175.2	21.18	4.6016	.0005
4. v/v, Gd. > Pr.	649.8	1	649.8	4.33	2.0817	.025
5. o/o, R > Pdo.	2,464.2	1	2,464.2	16.44	4.0538	.0005
6. o/v, R > Pdo.	451.2	1	451.2	3.01	1.7347	.05
7. v/o, R > Pdo.	1,805.0	1	1,805.0	12.04	3.4695	.0005
8. v/v, R > Pdo.	28.8	1	28.8	.19	—.4383	
Remainder	12,486.0	7	1,783.7	11.90		.001
Error (Within groups)	9,595.6	64	149.9			



No significant difference—overall group
No significant difference — good readers
No significant difference—poor readers

Figure 1. Significant differences ($p < .05$) between readers and modality groups.

Since the task did not appear to measure what it purported to, an analysis was made of good and poor readers' use of conventional orthography in the oral/visual task. Good readers, it was found, used conventional orthography significantly more often than phonemic alternatives ($p < .009$); poor readers, on the other hand, did not to a significant degree ($p < .49$). The suggestion is that conventional orthography relates semantic units more effectively than an orthography representing phonemic approximation to sound in the case of derived words. This generalization appears to hold true once some maturity in reading is achieved.

Preliminary to post-hoc comparisons, a significant F-value was found for the remaining comparisons independent of those tested by planned comparisons. Inspection of Table I, Remainder, reveals that the over-all F-test for "other comparisons" was significant ($p < .001$). Since the over-all F-test was found significant, any post-hoc comparisons were legitimate (Hays, 1963). It is not profitable to work out every conceivable comparison among the means and test each for significance; rather, the experimenter should come to tentative conclusions about where the large and interpretable effects lie (Hays, 1963).

A series of Scheffé post-hoc comparisons ($p < .05$) was made among modality variables with good and poor readers and real and pseudo-words combined. A refinement was then made by examining the modality variables separately for good and poor readers. A total of 18 comparisons was made, with 6 comparisons necessary for each category (over-all, good and poor).

It is evident from an inspection of Figure 1 that the v/v group was significantly different from all other groups on the over-all comparison. A hierarchy of performance (v/v, o/v, v/o, o/o) was discovered suggesting that conventional orthographic representation is a facilitative ingredient to the development of semantic relationships. The results are presented in Table II.

An inspection of the performance of good readers and poor readers by modality groups was conducted separately. For both specified groups the same hierarchy of performance as in the over-all comparison was revealed. However, the significant differences between groups were different. The results are presented in Tables III and IV.

For good readers no one group was significantly different from all

TABLE II. Summary of Post-hoc Comparisons for Modality, Over-all

	Mean	*o/v*	*Group* *v/o*	*v/v*
Mean Group		68.8	62.0	84.4
o/o	50.3	18.5*	11.7	34.1*
o/v	68.8		—6.8	15.6*
v/o	62.0			22.4*
v/v	84.4			

*Significant $p < .05$

TABLE III. Summary of Post-hoc Comparisons for Modality, Good Readers

	Mean	*o/v*	*Group* *v/o*	*v/v*
Mean Group		87.3	74.6	90.1
o/o	59.9	27.4*	14.7	30.2*
o/v	87.3		—12.7	2.8
v/o	74.6			15.5
v/v	90.1			

*Significant $p < .05$

TABLE IV. Summary of Post-hoc Comparisons for Modality Group, Poor Readers

	Mean	*o/v*	*Group* *v/o*	*v/v*
Mean Group		50.4	49.4	78.7
o/o	40.7	9.7	8.7	38.0*
o/v	50.4		—1.0	28.3*
v/o	49.4			29.3
v/v	78.7			

*Significant $p < .05$

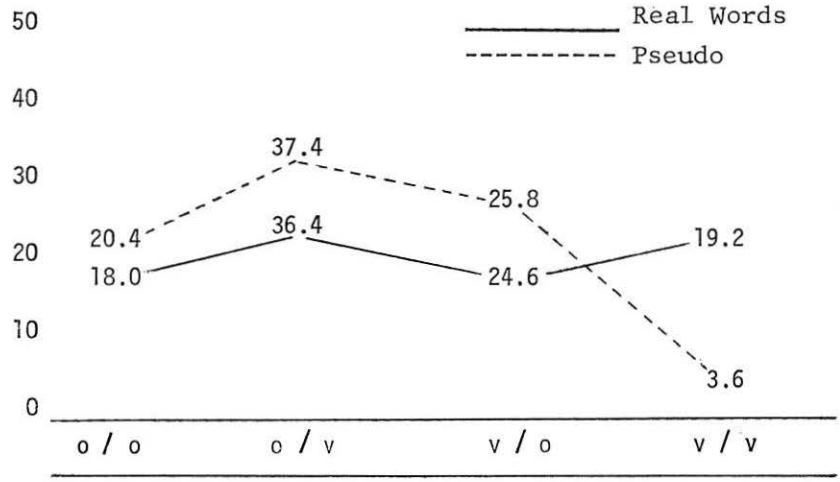


Figure 2. Difference of means of good and poor readers on real words and pseudo-words.

the others. Least differences appeared to be among the v/v, o/v, and v/o groups; none were significantly different from the others. For poor readers a different pattern of significant differences among groups was demonstrated. The v/v group was significantly different from all others. Least differences were observed among the o/v, v/o, and o/o groups, none of which were significantly different from any other.

Although good readers performed significantly better than poor readers on all four modality groups, it has been shown that performance on real words was significantly better than on pseudo-words in only three of the modality groups (o/o, o/v, and v/o). Also, it was observed in the post-hoc comparisons that the isolation of the reading ability factor resulted in a significant difference for the v/v group of poor readers, though not for good readers. The nature of the highly significant interaction is illustrated by the difference of the means of good and poor readers on real words and pseudo-words as illustrated in Figure 2.

The lower significant difference in scores observed in testing hypothesis 4 and the lack of a significant difference on hypothesis 8 seem attributable to this interaction. Poor readers in the pseudo-word, visual/visual cell responded to the treatment with better performance ($\bar{x} = 83.8$) than poor readers in the real word, visual/

visual cell ($\bar{x} = 73.6$). The results suggest that the visual/visual task was in substance different from the o/o, o/v, and v/o tasks as it did not necessitate the recognition of a deep structure. Poor readers were, hence, distinguished by this essential difference, while good readers were not significantly different in performance in this task than they were in the o/v and v/o tasks.

Conclusions and Implications

On the tasks which required recognizing regularities on a deep level (o/o, o/v, and v/o), good readers performed better than poor readers at a significant level ($p < .0005$). Also, good readers in the o/v task appeared to utilize the "common item" cue system which underlies conventional orthography, whereas, poor readers did not to a significant level.

The implication is that good readers are more competent in recognizing the underlying forms of words. By their knowledge of the phonological rules of the language and of the "morphophonemic" nature of the orthography, good readers (more than poor readers) in grade five were able to bypass the grapheme/phoneme correspondences and to relate the surface structures of words phonologically and orthographically to deep structures. The functional stimuli for the good readers appears to be the underlying form of lexical items; that is, a search for the semantic correspondence in derived words seems existent in the good readers. Neisser (1967) contends that word perception is a constructive synthetic activity. With the good readers a cognitive process of searching for deep structure is, therefore, apparent.

The results support a differential search pattern clarified by the effect of learning set upon problem-solving. When an individual experiences success with a particular method in problem-solving situations, he is apt to persist with that method even when it is inappropriate to new problem-solving situations (Klausmeier and Ripple, 1971). Readers who cling to the alphabetic principle encounter problems of efficiency since conventional orthography is not based on that single foundation. "In order to progress to more complex stages of reading, the child must abandon this early hypothesis, and come eventually to interpret written symbols as corresponding to more abstract lexical spellings. Normally he is able

to make this transition unaided as he matures and gains experience both with the sound structure of his language and with reading. It may be, however, that the difficulty encountered by some poor readers is related to the fact that they have not made this crucial transition [C. Chomsky, 1970, p. 297]."

Visual featural information shared by the graphic structural similarity in the v/v task clearly provided an analogic cue to semantic correspondence—this effect being especially pronounced by the performance of the poor readers. In terms of visual processing alone, good readers and poor readers are noticeably less different than perhaps previously thought. That is, when semantic correspondences are provided by visual features only, the analogic cue system is utilized by both good and poor readers as a facilitative cue in the identification of lexical relationships. However, when changing phonological properties are introduced, semantic correspondence is dependent upon the recovery of deep structure by underlying representation for analogy and the two groups, good readers and poor readers, performed differently.

It is suggested, therefore, that good readers have developed the strategy of attending to lexical identification (a search for meaning) rather than one of focusing upon surface structure. In this sense the perceptual construction of a word may be considered a more efficient search technique as it corresponds more closely to the higher order of complexity which exists in the English orthographic system. The "morphophonemic" nature of conventional orthography appears to be a more efficient system than one of "phonemic approximation" once some maturity in reading is achieved. The system exists as a practical means of identifying semantic relationships by the "elimination of redundant variation [Read, 1971, p. 24]."

The pedagogical implications of these findings for the field of reading suggest that children must learn the phonological rule system of English and must learn to relate such phonological knowledge to orthographic representation. Teachers need not be expected to fully understand competence models of the language for effective teaching in this area. It is obvious that so little is understood about the relationship of phonological knowledge and the interpretation of written symbols that a psychologically valid description is presently difficult.

However, it should be understood that oral language development is intimately related to reading ability. Assessments of readiness to read should include phonological performance, as well as assessments of disabled readers. A practical and easily constructed task may ask students to produce and/or recognize derived words after exposure to the theme form.

To facilitate the abstract relationship between phonological knowledge and the orthographic system, it must also be recognized that the orthography is not a system which relates grapheme to phoneme directly. The indirect relationship may then be illustrated by samples reflecting morphophonemic alternation to indicate that the appending of suffixes does not destroy a word to the creation of a totally new one, but, rather, it provides a method for using the represented concept as a different part of speech. While the semantic relationship is made, so should the orthographic one. An over-emphasis upon the alphabetical aspect of orthography may in fact serve to retard or curtail the necessary individual growth toward an understanding of the more sophisticated nature of the language system.

A useful strategy to prepare students for the changing utility of word recognition would be to prepare them with a set to search for the most economic stimulus held by an orthographic representation. Hereby, reading may be approached more reasonably as a problem-solving situation involving search and testing rather than a mere focus upon surface structure.

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APPENDIX A Sample Target Words by Alternation Type

REAL WORDS

s/š

discuss/discussion
suffice/sufficient
commerce/commercial
repulse/repulsion
grace/gracious

Sample Sentence Context

#41. discuss
S. To *discuss* a topic is to talk about it.
R. If a group of students talked about a topic, it would be a *discussion.*

Sample Response Alternatives

Theme Form	*Oral Alternatives*	*Visual Alternatives*
#41. discuss	a. dɪskʌšən	a. discushun
	b. dɪskʌtən	b. discussion
	c. dɪskʌsən	c. discushion
	d. dɪskʌkən	d. discuzion

PSEUDO-WORDS

s/š

lemace/lemacious
koness/konession
renulse/renulsion
dillerce/dillercial
plorice/ploricient

Sample Sentence Context

#62. lemace
S. To be *lemace* is to be groggy and unaware.
R. A person who is groggy and unaware when he gets up is *lemacious.*

Sample Response Alternatives

Theme Form	*Oral Alternatives*	*Visual Alternatives*
#62. lemace	a. ləmesəs	a. lemazious
	b. ləmekəs	b. lemashious
	c. ləmetəs	c. limashus
	d. ləmešəs	d. lemacious

Literacy Policy and the Emerging Technology of Readability

John R. Bormuth

The procedures for predicting and adjusting the comprehensibility of printed prose have steadily progressed from the status of an art, through that of a quasi-science, and are now emerging as a scientific technology having considerable generality and precision. Of special interest is the fact that this body of knowledge has much potential for enhancing the effectiveness of a nation's efforts to achieve a desirable level of literacy in its population while, at the same time, reducing the costs of those efforts. This paper outlines some of the arguments that favor accelerating the development of this technology in the developed nations and the founding of the technology in the mother tongues of developing nations.

Modern man owes much of his material and cultural prosperity to his ability to organize diverse scientific theories into technologies that allow us to design and manage complex systems that produce abundances of the things he wants. While most of these technologies have arisen out of the physical and biological sciences, a few (chiefly those based on economic theory) have been based on theory developed in the younger social sciences. One of the latter is technically referred to as the field of comprehensibility or more commonly by the general term readability. This technology consists of a rapidly growing set of procedures for making accurate predictions, manipulations, and evaluations of the comprehensibility of printed language. The objectives of this field are to enable us accurately and economically to select and adjust prose so that it is suitably comprehensible for its intended readers. A recent series of studies (e.g., Bormuth, 1966, 1969, and 1971; Coleman, 1974, and Coleman and Miller, 1968) have shown that many of the specific objectives of this field have been attained and that many of the remainder lie within the range of our present scientific capabilities. Nearly all of this research has taken place within the United States and has studied the English language.

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As this field progressed from the status of an art and approached that of a precise technology, it attracted increasing amounts of interest from those involved in formulating and carrying out the literacy policies in both developing and developed nations throughout the world. This interest was elicited by the fact that modern readability theory provides us with a powerful tool for supplementing and greatly enhancing the effectiveness of existing and planned literacy programs and for reducing the costs of those programs. Over the past several years the author participated in some of the research that formulated modern readability theory, and he has consulted with a number of agencies and scholars from other language communities about the desirability of developing a similar technology for their mother tongues. This paper summarizes the general arguments in favor of conducting this research in developing nations and accelerating it in the developed nations.

Social Utility of Readability

The basic reasoning by which readability is justified is fairly simple. In bare outline, it is this: the wealth, cultural richness, and social stability of the developed nations of the world stem, in large part, from their ability to gather, organize, teach, and apply knowledge to the solution of problems. Printed language plays a large and indispensable role in gathering, organizing, and teaching the basic knowledge upon which the prosperity of the developed nations rests. And that prosperity depends upon nearly all of the members of the population of those nations being able to acquire large amounts of information efficiently through the use of printed language. The technology of readability provides one of the two major devices for regulating people's literacy.

Function of Language. Some philosophers like to observe that lower animals are the servants of nature while man is the master of nature. It seems clear that much of man's success arose from his ability to acquire knowledge about his natural and social environment, to communicate it to others, to accumulate large stores of it, to organize it into technologies that bear on problems, and then to apply that knowledge to solve problems. Knowledge is born in the experience and thought of a single person. If each person had to rely solely on his

own experience for his supply of knowledge, he would accumulate only the crudest understanding of his environment within his lifetime. But man has a powerful tool at his command: language. Language provides man with the ability to accumulate amounts of knowledge that far transcend his own time in history and his own personal experiences.

Limitations of Spoken Language. Early man was forced to rely almost exclusively upon spoken language, and this severely restricted his development. Spoken language provided a relatively poor vehicle for collecting knowledge from people who were widely separated in time and space. And the amount and accuracy of the knowledge collected was limited, because knowledge had to be stored in human memory, a storage device of limited capacity where knowledge is subject to distortion and, periodically, to total loss through death. Thus, the knowledge available to a whole society accumulated only very slowly.

Spoken language is an equally poor device for organizing knowledge. Knowledge reaches its highest level of usefulness when it has been abstracted and summarized in the form of the terse statements called laws and when those laws are organized to form connected theories. To cast knowledge into this form requires the scholar to view simultaneously large numbers of separate lists of knowledge, to assemble them into precisely related patterns, and then to preserve these patterns of knowledge. Obviously, when only spoken language is used, human memory and human mental processes prevent more than limited activities of this sort.

Invention of Writing. The invention of written language improved but did not fully remedy this situation. Writing did make it possible for man to accumulate, accurately record, and organize more knowledge. And it did make it possible for him to communicate with people widely separated in time and space. But the pen alone is but a poor tool for a task of the magnitude that man faced.

In the ancient world, centers of learning possessed meager libraries. The process of copying books by hand simply made publication too expensive and too slow to permit the rapid accumulation, communication, and organization of knowledge. The later medieval

"universities" in Italy and France were no better at this task, for the same reason. Throughout pre-modern times technology advanced at a pace that was only slightly faster than when man could rely only on spoken language.

Mass Publication. The development of inexpensive paper in Spain and of typography in Germany facilitated what some have called the knowledge explosion, the rapid increase of knowledge that has provided the basis for the technologies that produce the wealth of our modern societies. Printed language has become an integral part of man's daily activities. It has become an indispensable part of the communications systems by which modern societies organize and coordinate much of their industrial, cultural, and political activity. Goods and services are produced by organizations that are far too complex to be managed solely by spoken language; hence the business letter, the memorandum, the purchase order, the production manual, and the advertisement have become standard items among the multitude of different kinds of printed communication employed in most industries. The book and the magazine have similarly replaced spoken language as a principal means of communicating human cultural heritage. And the newspaper, news journal, and books on topical issues play a central role in providing people with the information and ideas on which to base their decisions about how to govern themselves.

Alternative Media. The manufacturers of electronic communications devices have periodically offered their machines as replacements for printed media. But so far they have been only modestly convincing. The invention of radio, motion pictures, and television, for example, scarcely affected the use of newspapers, journals, and books. The rates of publication of all three have continued to grow steadily. The electronic media have failed to sweep printed media aside because of their extremely high costs, inflexibility, and ineffectiveness in most of the new applications proposed. For example, to justify expenses a television program must be shown to very large audiences. As a result, it must deal with content that is of broad interest—primarily light entertainment and superficial coverage of news. This is not to say that electronic media do not perform some tasks superbly well, but

in those activities where information must be given in depth, where it must be referred to and repeatedly used by a small number of people, where it must be studied at a time selected by the user, or where only a part of the content may be of interest at a given time, the electronic media usually fail to compete successfully with the printed word. Consequently, unless there is some radically new invention that cannot presently be foreseen, printed language will continue to provide the basic means by which developed societies collect, process, and teach the information on which their existence depends. And the members of those societies will have to continue to attain a high degree of literacy.

Mounting Importance of Print. There is evidence that literacy is becoming more, rather than less, important as the so-called developed societies develop even further. In most democratic societies of an earlier time, literacy was essential for obtaining knowledge of political events and, therefore, for performing a person's duties as a responsible citizen. Nonetheless, man's economic productivity was not seriously limited if he was unable to read. Technology changed very slowly, so he could acquire a high level of skill through apprenticeship, and could feel confident that those skills would serve him throughout his life. His work required little or no reading. The only people for whom literacy was essential were the handful of people in service professions

Today, however, unskilled jobs are increasingly being taken over by automated machines and are being replaced by jobs requiring higher levels of skills. Moreover, it appears that even these new skilled jobs will change or disappear as technologies continue their rapid pace of change, replaced by jobs that require even higher levels of skills. Thus, new skilled jobs require high levels of literacy for two reasons: the jobs themselves usually require some reading skills, and a person cannot be trained efficiently by apprenticeship alone. He must learn much of the job by reading. It appears, therefore, that in the future technically advanced societies will have to devote more of their resources to raising a large proportion of their citizens to levels of literacy heretofore achieved only by a small proportion of their populations. Evidence that this is actually a trend in modern societies can be seen in the high levels of unemployment

among the poorly educated while labor shortages occur in jobs that call for high levels of training. As additional evidence, a recent survey (Sharon, 1972) showed that roughly 42% of the people in the United States spend over 60% of their time on the job reading.

Readability and Literacy

Many people can be easily persuaded that literacy is essential to individuals and to nations that seek cultural, social, and material well-being. Moreover, they seem generally willing to sacrifice time and resources to attain an adequate level of literacy. There is little difficulty in obtaining agreement on these matters—as long as we confine ourselves to broad generalities. But when we focus attention on a specific situation, we find evidence of a growing skepticism about the value of the programs that attempt to produce literacy. In the so-called developed countries we are observing many instances of resistance to spending tax moneys for instruction in reading skills. And in the developing countries we find that large numbers of parents are not enthusiastic about enrolling and keeping their children in schools, and we also find that governments are sparing in their support of literacy programs. This lack of support may be interpreted in a number of ways, but it is clear that the results of the literacy programs, themselves, have not produced enough benefits to enlist a vigorous demand for those services (Bormuth, 1968). An important explanation is that literacy has been conceived so narrowly that literacy programs have been almost certainly doomed to failure.

Faulty Conceptions of Literacy. Two major misconceptions have dominated most policy that attempts to deal with the literacy problem. The first is the proposition that *a person is literate as soon as he can merely speak the words he sees in printed form*. The second is that *the best, and perhaps the only, method of increasing people's literacy is to teach them more skill in reading*. These are by no means the only conceptual problems that have plagued literacy programs. For example, much effort has been expended on teaching people to read only to discover that in their society there was almost nothing available for them to read and no mechanisms for producing and distributing materials. However, only the first two misconceptions about the nature of literacy are of direct interest here.

Consider the proposition that a person has automatically achieved literacy if he has learned merely to decode printed words into spoken words. Nearly everyone would agree that the mere decoding of words, if that were the only skill a person learned, has little utility. Only radio and television announcers and perhaps a few others could find any use for that isolated skill. The rest of us must employ our reading skills to obtain information, and we do not consider ourselves as literate unless our skills serve effectively to help us obtain that information. However, this popular misconception probably arises from different and more seductive reasoning: all normal school children understand their native language before they enter school, and have mastered the comprehension skills necessary to learn what they are told in that language; writing is nothing more than an encoded form of their language; therefore, when people have been taught merely to decode written language into spoken language, they will thereafter be able to understand and learn whatever information they encounter in printed language.

The chief problem with this reasoning is that neither its major nor its minor premise is universally true. Few people understand all of the spoken language they hear. And written language is usually far more elaborate, complex, and difficult to understand than spoken language. Although research lends support to the assertion that most people fail to understand all of the spoken language they hear, this point can be sustained without recourse to a technical discussion of that literature. If the reader reflects for a moment on his own experience, he may recall numerous instances in which he failed to understand spoken language that seemed to be understandable to others, and he may also recall instances of others failing to understand speech that seemed perfectly clear to him.

Similarly, written and spoken language are not merely different encodings of a single form of the language. It is true that written language evolved from spoken language and it is equally true that spoken and written language continue to share much in common. However, the demands that face a writer differ from those faced by a speaker. The demands faced by a speaker place a high premium on immediacy and responsiveness to the listener; the demands faced by a writer place a high premium on organization, clarity, and precision. The writer has at his disposal, also, resources that are not available to

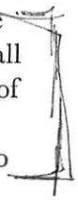
a speaker; he has the time to ponder, organize and polish his statements. As a result, written language contains highly complex sentences organized into still more complex paragraphs, sections, and chapters. By contrast, spoken sentences tend to be short, and rarely does one hear a speaker in ordinary conversation string together more than two or three sentences before one of his hearers speaks to clarify, modify, or extend what he has said. Thus, written language certainly differs in major respects from spoken language. It is highly unlikely that a person who has been taught only the simple word-naming skills will automatically, without further instruction, be able to comprehend everything he reads. Accordingly, reading must be seen as a socially useful process, a process that includes not only decoding printed language but also comprehending the information contained in the language people need to read.

Now consider the second proposition: that the way we should approach the problem of increasing people's literacy is to teach them additional reading skills. Assuming that reading skills include both decoding and comprehension skills, most would agree that such instruction is certainly an essential ingredient of any literacy program. But increasing numbers of scholars are now taking the position that other methods are also essential if we are to achieve the goal of literacy programs without sacrificing exorbitant amounts of our resources. Indeed, they argue that the goals of a literacy program can be achieved successfully and economically only by using some combination of methods.

Pragmatic Concept of Literacy. To understand this position it is necessary to begin with a reasonably clear concept of what societies and people within them are trying to buy when they devote large portions of their lives and large amounts of other resources to attain literacy. Most people will acknowledge that there are many things written in their language that they cannot comprehend. Moreover, they are likely to ridicule the notion that it is desirable for them or anyone to reach a state of perfect literacy. Consequently, people probably have some rather pragmatic concept in mind when they use the term literacy. In this paper we employ the concept that *a person is literate when he can satisfactorily comprehend whatever written materials it may be socially or personally desirable for him to read.*

We can gain at least two important advantages by viewing literacy in this way. The obvious advantage is that it potentially provides literacy programs with a goal that is closely tied to human needs. And it makes obvious the fact that we can influence a person's literacy in *two* ways. We can either provide him with more instruction or we can provide him with materials that are more comprehensible to him. In either case, the result is the same: he comprehends at a desirable level the materials he needs to read; we say *he becomes literate on those materials.*

Instruction Versus Readability. Readability deals with the methods by which we regulate the comprehensibility of written language. It should be understood that reading instruction and readability are complementary approaches, and that neither approach is fully viable without the other. Their fundamental relationship might be explained in this way: language is a system of symbols that performs the function of signalling information. We encode information into language and others decode language to obtain that information. This signalling system consists of words and other lexical features that signal concepts, and it consists of syntactic features that tell us how and in what order we should combine the meanings of those concepts. A person's reading ability is determined by the extent of his knowledge of these features; the readability of materials is determined by the difficulty of the features it contains. Therefore, a person's literacy is determined by the degree to which his reading skills match the skills demanded by the linguistic features contained in the passage. The object of reading instruction, then, is to teach people to interpret all the linguistic features they are likely to encounter, and the object of readability is to regulate materials so that they contain only those linguistic features that the intended reader is likely to know how to interpret.



Neither readability control nor reading instruction, taken alone, provides a very sensible or economical way to deal with society's literacy problems. Consider the instructional approach first. To begin with, we know from research (Bormuth, 1968) and experience that we do not yet have the technical and scientific knowledge necessary to teach people all of the comprehension skills they would have to learn if we were to use instruction as our only approach. And the

instructional approach inevitably involves providing large amounts of instruction for large numbers of people. Finally, this approach affords us with no way to limit costs. The costs are determined by the number of skills we set out to teach; the number of skills that we need to teach is determined by the linguistic complexity of the materials people need to read; and the instructional approach provides no way to help us limit linguistic complexity.

Now consider the readability approach. There are some costs associated with developing a technology of readability. Scholars have to be trained to do the research, the research itself has to be conducted, and editors and educators must be trained to use some of the techniques. However, the costs associated with developing a technology of readability are trivial compared to the costs of not developing one. Into the latter we must reckon the moneys wasted on materials that cannot be understood, the moneys that must be spent on added instruction, and the personal and national development that must be forgone because of a failure to acquire the knowledge necessary to cope with the modern world. Consequently, readability control and reading instruction must be seen not as alternatives but as mutually complementary approaches, each capable of supplementing and enhancing the efficiency of the other.

Readability and reading instruction are complementary in another important sense. We are experiencing very little success in teaching people language comprehension skills. That is, we have not been able to find evidence that our teaching has much effect on students' comprehension abilities that could not be attributed merely to learning that takes place without instruction in those skills (Bormuth, 1968). Scientists have not yet developed workable theories of the nature of the comprehension processes and how they may be taught. Since readability research attempts to identify the kinds of language features that are involved in the comprehension processes, people who know how to do readability research have mastered many of the skills necessary for research on comprehension theory. And their skills will be essential for adapting that theory to the design of instruction for teaching the comprehension of their native language.

Two comments should be made about the limits of readability control. First, it attempts to control only the comprehensibility of what is said in print; it in no way deals with subject matter. Second,

readability, at least in the present state of that science, is not suitable for use with works having literary and aesthetic pretensions. It merely provides a set of techniques for altering the ease of materials, and it assumes that subtle nuances, connotations, meter, and the like can be sacrificed in this process.

Readability in Developing Nations

Now let us examine the main reasons why a developing nation might wish to embark on an effort to develop a technology of readability for its mother tongue. At this point it is necessary to exercise caution. Developing nations differ enormously in both resources and goals, so any general assertion about what will be good for them will almost certainly be wrong in specific nations. Hence, the following arguments might be said to be typical of the ones that are usually relevant in the formulation of national policies. But they must be carefully examined before they can be regarded as valid for a particular nation.

Three considerations stand out clearly. First, many developing nations seem to have firmly committed themselves to a democratic form of government, a form of government in which all power is ultimately reserved to the citizen and in which the citizen ultimately makes all important decisions. Second, many peoples seem to have decided to secure a higher standard of living for all of their people by mastering the technologies of modern industry. Third, with productivity comes wealth and with wealth comes the surplus of time that people need to participate in arts and cultural activities. And many nations appear to be determined to provide as many people as possible with the opportunity and background necessary to participate in the pleasure of their cultural heritage.

Many developing nations have done much to initiate universal education and to improve publicly financed education at all levels. One of these improvements is a plan to modernize instructional methods of supplying students with free textbooks. In the past, nearly all instruction has followed traditions similar to those established in the Middle Ages before the invention of printing: the "lecture-notebook" method in which the teacher reads to students a book he has written (he was called a *lecturis*, the latin word for "one who reads"), and the student's task is to obtain the teacher's knowledge by copying verbatim the lecturis' words. This is too slow

a method to transmit the large amounts of information necessary for citizens of modern societies; it is probably often ineffective because the lecturis' explanations are frequently incomprehensible; and it does not provide students with practice in the necessary reading skills. Consequently, the carefully prepared textbook is fast replacing much of the lecture function of the teacher, and the teacher is moving into the role of a diagnostician of learning problems and the role of a mentor who helps the student evaluate, integrate, and apply his knowledge.

However, this shift in educational objectives and methods presents a complex of problems to be solved. In developing nations the transition has meant that new curriculum guides have to be planned and written; teacher training has to be revised; and, because textbooks have seen only limited use throughout much of the world, guidelines have to be developed to insure that the textbooks are of high quality. Many of the textbooks presently available, for example, often omit a clear organization of the content, an index and glossary of terms, and so on; their contents are sometimes ill-chosen, inaccurate, and poorly coordinated with national needs and national curricula: and they are often written in language that is too abstract, too complex, and too poorly organized to be comprehended by students.

In the English-speaking nations there is a substantial body of research on the question of what makes a material comprehensible and a technology has been developed that permits us to effectively predict and control the comprehensibility of materials. Recent research in the French, Finnish, Spanish, and Russian languages has shown that this technology can be developed and applies with equal precision in any language; the cost of doing this is nominal compared to the costs of failing to develop that technology.

Summary

The rationale for developing a technology of readability can be summarized in this fashion: First, the developed nations of the world have been able to achieve their material wealth, political stability, and cultural affluence because nearly all of their people are literate. They are literate not merely in the narrow sense that they can decode printed language into spoken language, but they are literate in the broader sense that many of their people can adequately

comprehend the language in the materials that they need to read. Second, there are two complementary ways to influence a person's literacy. On the one hand, we may instruct him in the skills necessary to read more of the materials he needs to use. Reaching an acceptable level of literacy in a nation unavoidably involves a considerable investment in instruction of this sort. But this approach always places a heavy burden on the financial resources of a nation because it involves financing a massive educational effort. On the other hand, we can greatly moderate these costs by developing a technology of readability and then employing that technology to reduce the number of skills a person must learn in order to adequately comprehend the materials he needs to use. The result of this approach is that more people can obtain more information from more printed materials and do so at great savings to themselves and to the nation. Third, many hitherto backward nations have embarked on programs of development. Both they and the more advanced nations would be well advised to build a science of readability as one element that will contribute to that development.

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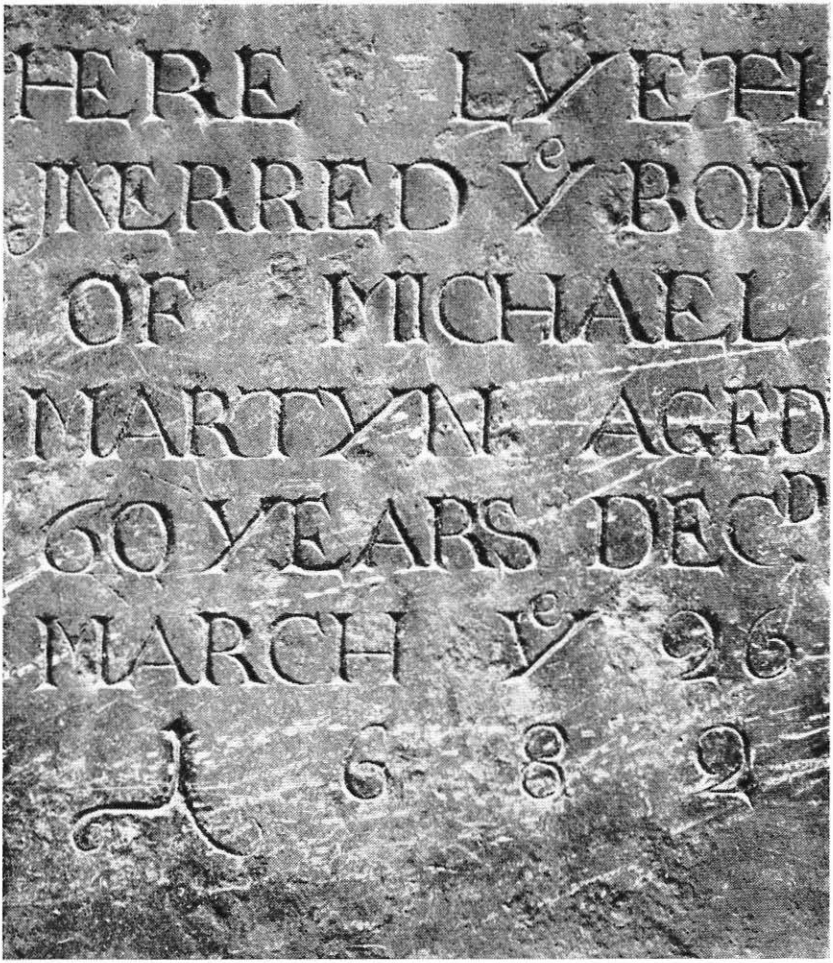

Typical of the way the Boston area stone cutters inscribed the late seventeen-century gravestones. Charlestown, Mass., 1682.

Inscriptions of Our Past

Francis Duval and Ivan Rigby

A selection of inscriptions on American gravestones from the seventeenth and eighteenth centuries are illustrated. A brief introduction comments on the urgent need for their recording before further damage is inflicted upon them.

To anyone who cares about American art forms, it is clear that our early gravestones constitute a rich heritage and that many of them are of museum quality. Nevertheless, unlike museum objects which are restored and sheltered by institutional curators, they are destined by their very nature to remain scattered over half a continent at the whim of the elements and the merciless defacing by vandals whose physical energies, coupled with ignorance, are making many a burial ground a battlefield.

The virtually endless symbolic art inherent in so many of our gravestones has fascinated generations of onlookers but never so much as during the last few years as the country is taking stock of all its native arts in anticipation of the Bicentennial in 1976. Very little documentation exists on early American gravestones; a few books have appeared but they leave much to be desired in one way or another being confined to a particular area or to a particular chronology and for the most part badly illustrated. We have embarked on this current project in order to alleviate this sorry situation, travelling extensively from Massachusetts to Virginia in search of specimens of this fascinating art form. A most comprehensive collection has evolved comprising thousands of examples in the form of black and white and color photographs in addition to several hundreds of plastercasts and metallic impressions.

The alphabets used on our earliest gravestones were those found in seventeenth-century books that made the journey across the

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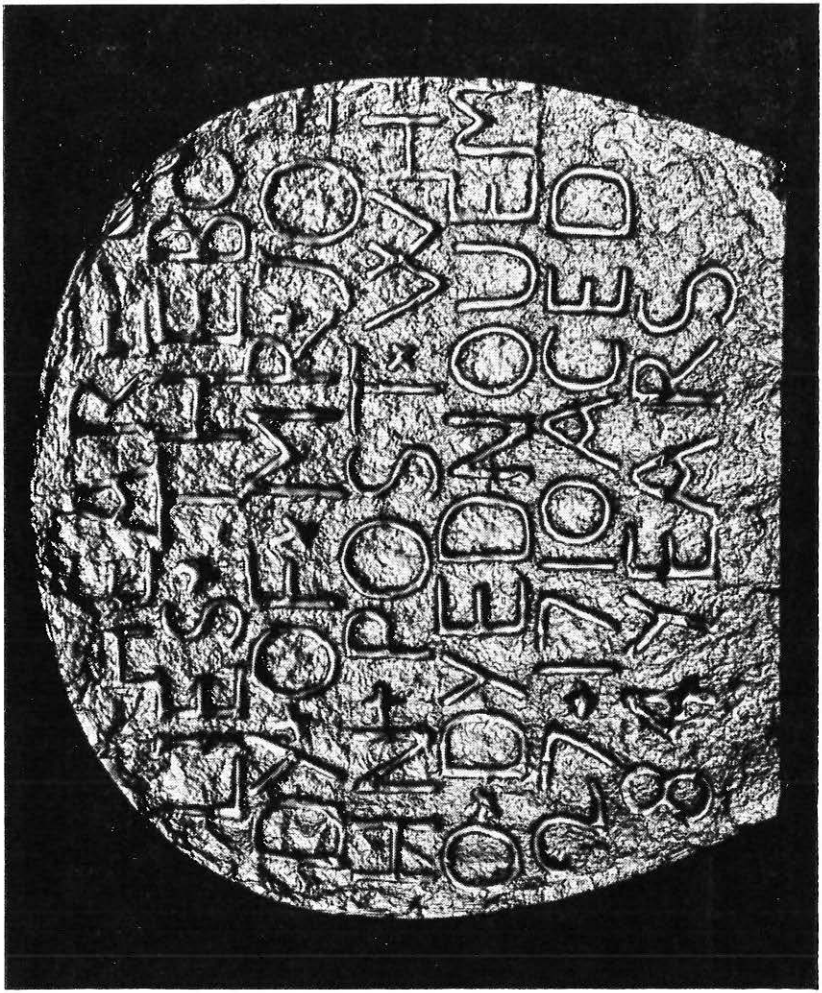
Atlantic. However, through necessity, a freer interpretation of the letterforms soon surfaced under the strong influence of the broadsides, primers, and proclamations of the time. Their execution in a hostile medium by the artisans who carved them is a miracle considering the simple tools available. Be it slate or redstone, quartzite or sandstone, these durable materials still afford us the opportunity of appreciating these early gravestones as perhaps the most genuine of all American folk art forms.

A quick look at what little remains on gravestones in some of our old burial grounds will convince anyone who cares of the urgency in recording this legacy before more gravestones revert to eroded, frittered, and characterless slabs of stone. We have found our endeavor a most exciting and rewarding proposition, and we urge others to seek out and record examples in their own areas.

Large or small, crude or sophisticated, erudite or illiterate, lengthy or abbreviated—these gravestone inscriptions tell us of the talent and resourcefulness that existed in our not-so-distant past and of a breed of artisans who catered to the common man's quest for some immortality.

Crudely-cut stone displaying a minimum of inscription: date, initials and age. Kingston, N.Y., 1712.

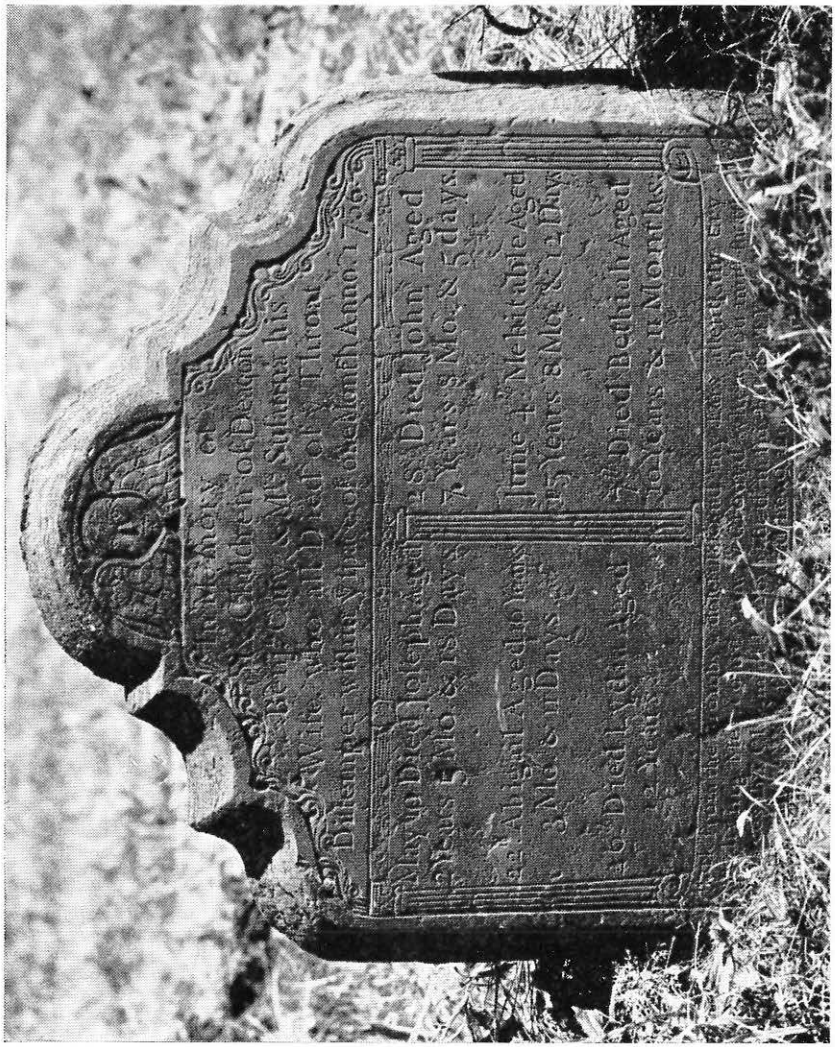


Semi-circular gravestone; metallic impression shows more than the stone original its crude but very effective lettering carving. Norwichtown, Conn., 1710.

Metallic impression of gravestone carved in Boston and most likely the work of Joseph Lamson; over-all design is well-integrated. Stratford, Conn., 1713.

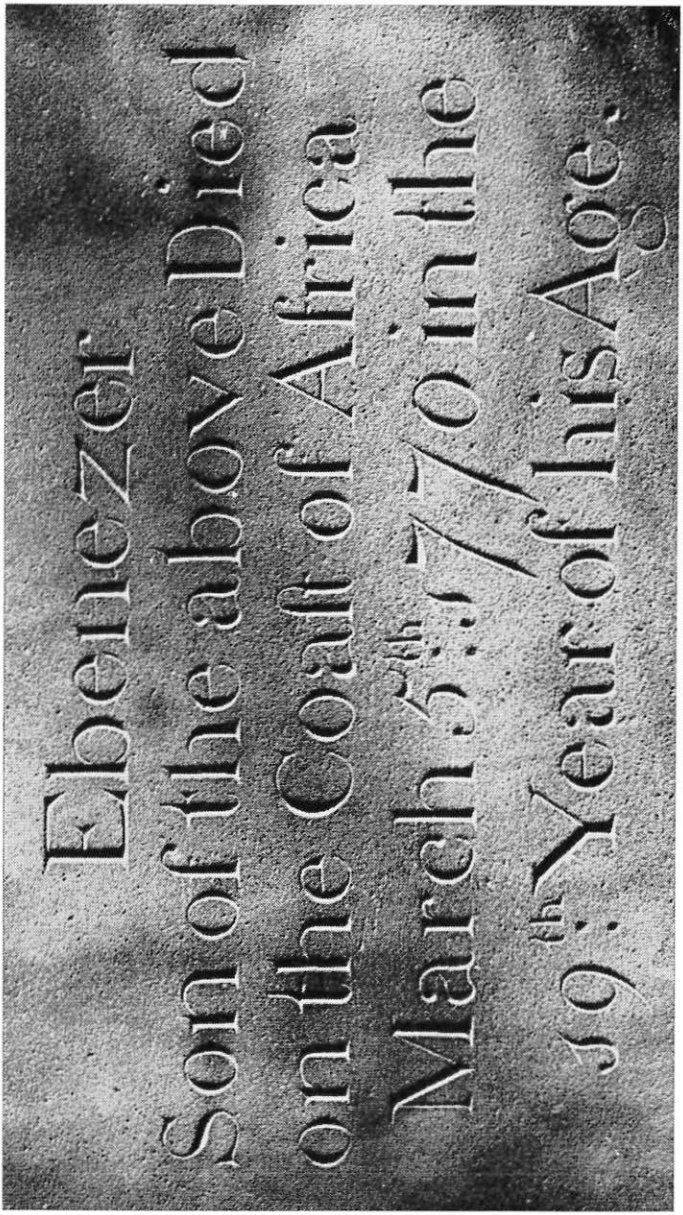
Footstone detail with unusual type handling. Milford, Conn., early eighteenth century.

Plaster cast detail of the inscription on Hannah Waterman's gravestone. Norwichtown, Conn.

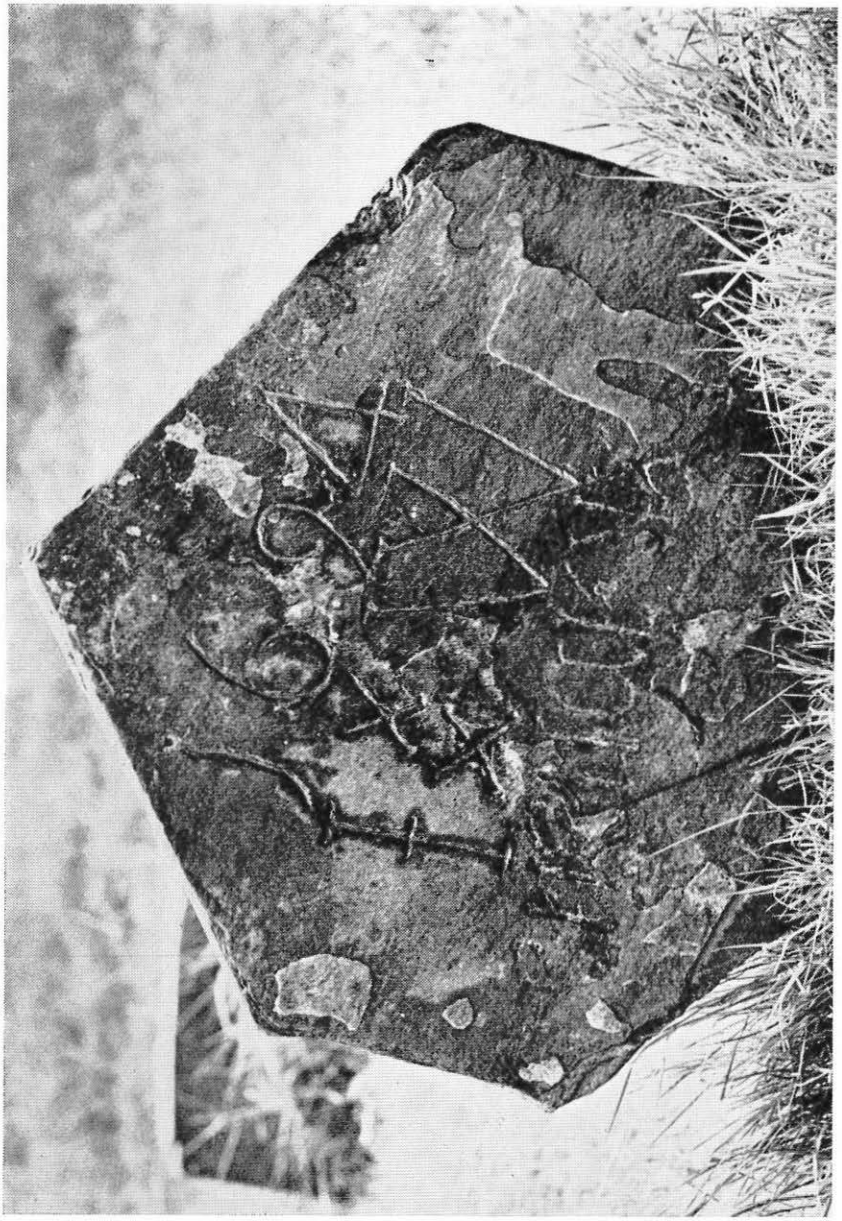


Strong type emphasis for six children who all died within the span of one month. Bristol, R.I., 1756.

Plaster cast detail of gravestone with still-visible rule lines for lettering surrounding the Adam & Eve design. Bristol, R.I., 1767.

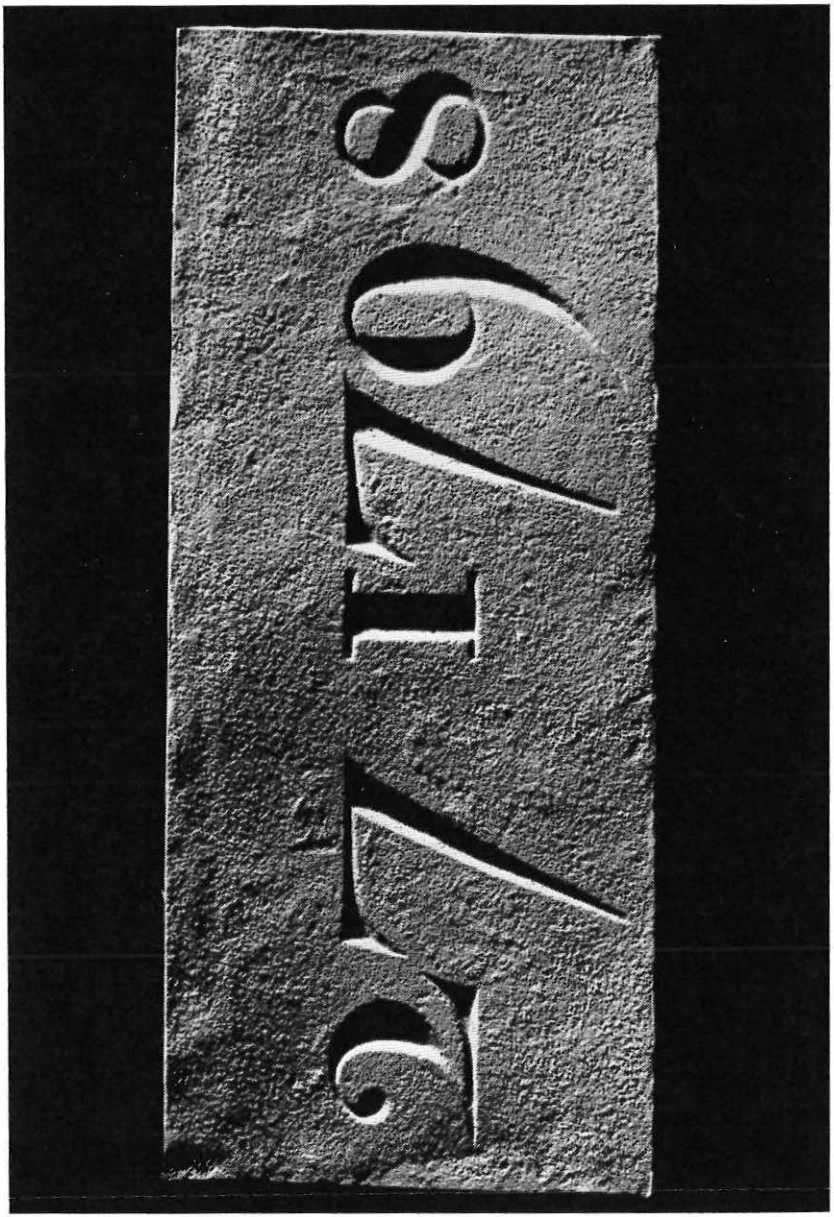


Lettering detail showing high degree of type knowledge. Huntington, Long Island, N.Y., 1770.

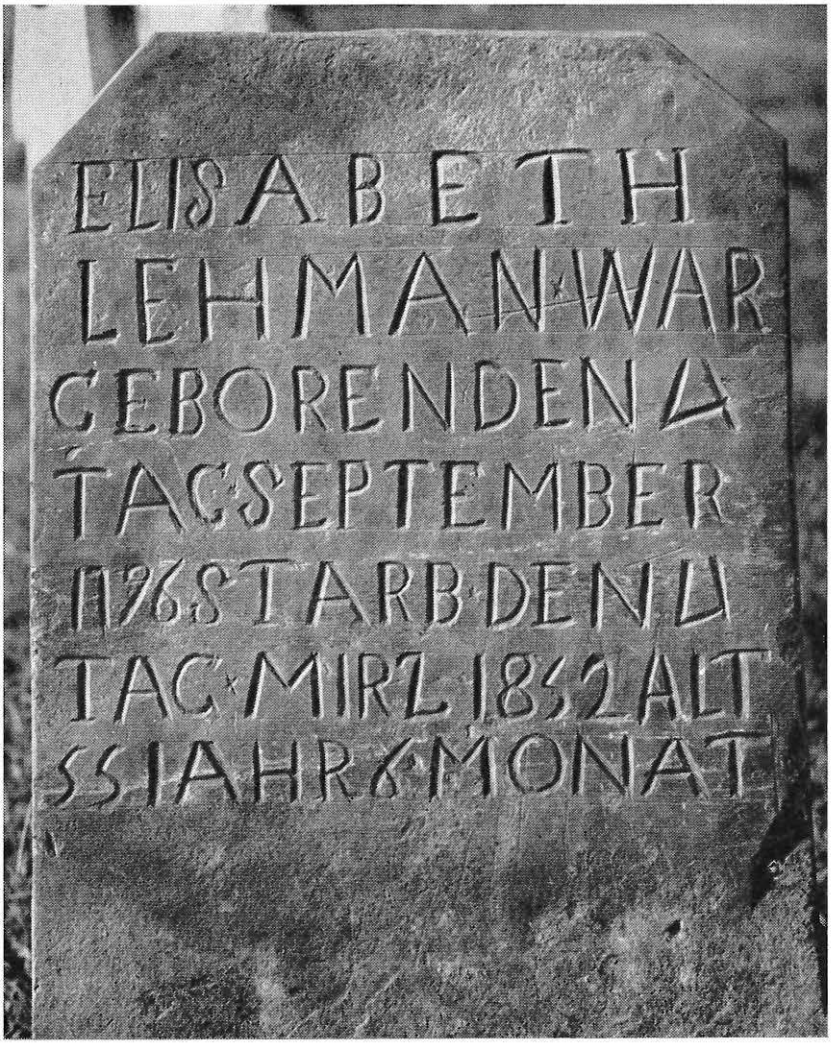


Small cryptic gravestone, very unusual and badly frittering away. Stratford, Conn., 1694.

Very effective type handling with some rather striking lettering innovations. Middletown, Conn., 1696.



Plaster cast detail of elegant type handling. Elizabeth, N.J., June 27, 1798.



Small gravestone—obviously "home-made" and touching in its simplicity. Mannheim, Pa., 1796.

A Bibliography in Character Recognition: Techniques for Describing Characters

R. Shillman, C. Cox, T. Kuklinski, J. Ventura, M. Eden, B. Blesser

A bibliography is presented in the field of character recognition. Many of the references are from the fields of engineering and psychology and deal with various techniques for describing machine and hand-printed characters.

The following bibliography lists references that we have compiled during two years of work on various aspects of character recognition. Our attempt at searching the literatures related to engineering, psychology, and character formation was to combine the relevant portions of all three so as to form a unified approach to the area of machine recognition of multifont and hand-printed alphanumerics.

In pursuing our research we have placed major emphasis on sources relating to the application of cognitive psychology to the character recognition problem. Consequently, we feel that the bibliography is not a totally balanced view of the entire character recognition field. The sources dealing with engineering-oriented techniques were chosen from the vast number of such articles so as to exhibit the range of thought which has been considered. A few references which we found particularly useful for investigating the relevance of character formation to character recognition were included.

References included under a specific heading may be applicable to other areas; for example, a listing under the hand-printing heading may provide techniques which are useful for the recognition of machine-printed characters. The authors would appreciate any additions to this bibliography.

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OUTLINE OF THE BIBLIOGRAPHY

I. General References and Review Papers
   A. Engineering
   B. Psychology

II. Engineering Descriptions of Characters
   A. Techniques Applied to Machine-Printed Characters
   B. Techniques Applied to Hand-Printed Characters
   C. Techniques Incorporating Contextual Information

III. Psychological Descriptions of Characters
   A. Attempts to Identify the Distinctive Features of Printed Characters
   B. Attempts to Describe Character-like Shapes

IV. Insight Through the Study of Character Formation

V. Relevant Journals
   A. Engineering
   B. Psychology

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V. Relevant Journals

A. *Engineering*

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Cybernetics
IEEE Transactions on Computers
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Computer Graphics and Image Processing
Information and Control
International Journal of Man-Machine Studies
Pattern Recognition
Visible Language

B. *Psychology*

American Journal of Psychology
Journal of Experimental Psychology
Perception and Psychophysics
Perceptual and Motor Skills
Psychonomic Science
Visible Language

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The Humanist in the Computer Lab

Joseph Raben

The attempts so far made to utilize computers in studying the humanities have resulted more in a fundamental analysis of the subject areas themselves than in any significant results. The problems of inputting and outputting, of determining what processes may appropriately be employed, and of developing new processes not derived from the customary numerical approaches which presently dominate computer thinking—all these have retarded what had been expected to be a dramatic advance into a new order of humanistic criticism. The most substantial accomplishments to date have been the rationalized lists of words (dictionaries, indexes, and concordances) for which the computer's capacity to sort rapidly without fatigue or error has accelerated production of these traditonal aids to scholarship. A new breed of humanistic scholar now evolving—highly trained in the humanities and at the same time in those aspects of computer science genuinely relevant to his studies—will contribute to the creation of new programming languages specially designed for this work, assist in the training of others who follow, and help to guide computer-assisted instruction beyond the mechanistic mode in which it currently operates.

If, as we have been told, future historians will refer to ours as the Age of Analysis, an apposite illustration of the concern for probing the processes of the mind and of society may well be found in the activities of literary and linguistic scholars who have cast their professional careers in the mold of computer-aided research. Much of the drive for understanding through the close examination of accumulated details typifies a new species of scholarship, which in general parallels the trends we can discern in the physical sciences, the social sciences, and the management of all our institutions—including government. And as this trend was both the father and the child of the computer, so the student of verbal expression often finds himself involved in the challenges and the frustrations of electronic technology. On the whole, the encounter has been beneficial, even though dramatic results are coming more slowly than was originally expected.

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And among the present benefits of this entry of computers into humanistic scholarship (or the reverse, the entry of that scholarship into the realms of the technocrat) has been a scrutiny of the basic materials of our discipline of a sort never before required.

Even the initial act of translating our verbal materials into a form comprehensible to machines intended almost exclusively for numerical processes has forced us to consider the most trivial aspects of these materials: how to indicate true capital letters when the only font available is all-capitals; how to include foreign accents and diacritics; how to indicate line-endings in poetry; how to represent non-roman alphabets and characters. Never before has there been such a need to discriminate the full stop that ends a sentence from that which marks an abbreviation, the apostrophe from the inverted comma, the question mark or exclamation point that ends a sentence from one that merely ends a parenthetical phrase within a sentence. Innumerable projects to explore the intellectual profundities of a literary corpus seem to have foundered in the shoals of irrational input conventions. At the other end of the process, the same complexities bedevil the computer-oriented literary scholar who, commanding a machine that will do almost anything it is told to, and nothing without being told, often appears lost in the maelstrom of dizzying possibilities and maddening impedimenta.

And in between, in the process for which all this anguish is suffered, what analytical processes will we order to be performed? Will the scholar be concerned with quantities and therefore concentrate on average words per sentence, average sentences per paragraph, average length of word, deviations from these averages, and similar numerical values? Many literary projects aided by computers are currently moving along these lines, perhaps because so many routines for this type of work have already been written in other disciplines and can easily be adapted. Sometimes these numerical exercises are ends in themselves; often they are intended to prove or disprove the authorship of one or more texts. Another approach has been to attempt to get at subliminal levels of meaning by grouping key words into semantic categories, either manually by the editor or automatically by the computer. The manual procedure creates the risk of inconsistency as the human mind runs through its cycles of attention and inattention, while the electronic approach goes too far

in the opposite direction, applying rigid instructions with little leeway to interpret the data in new and unexpected ways. Some of the surprise outputs from these unanticipated results of computer processing of literary texts have often been more informative than the results the investigator sought, for they have often forced him to think out problems he had never considered. For example, we may say that we are counting words, but what exactly is a word, that is, when has a word changed enough to be another word? Are *man* and *men* two words? What about the possessives, *man's* and *men's*? Do we include or exclude *mankind* when it is equatable with *men*? What about compounds containing *man* as an element: *man-about-town*, *man-at-arms*, *man Friday*? And then the derived forms: *manlike*, *manly*, *manliness*, *man-made*, *mannish*, *mannequin*, *man-of-war*, *man-size*, *man-slaughter*, etc. Clearly, at some point, we have departed from the central concept of *man*: a man-of-war is a ship, a mannequin is a woman. In trying to establish a line so firm that even a dull-witted computer can recognize it, many lonely scholars, who dreamed of putting the drudgery of their investigations on the back of a willing and industrious servant, are now wrestling with a whole new set of classification problems, and finding themselves frequently working back to fundamentals rather than forward into the territory they hoped to conquer.

Inevitably, the type of classification which has accounted for the great bulk of literary data processing has that which does not require a fundamental principle but rather a traditional and arbitrary schema. In the making of verbal indexes and concordances, literary scholars have found an ideal combination of tradition and novelty: the compiling of alphabetical lists, with or without some context to suggest meaning and usage, has a history extending to the middle ages, while the tedium coupled with concentration once required to produce such lists through the manual sorting of paper slips has made this operation a natural candidate for computerization. Almost the entire history of this field of research can be observed in the efforts of Father Roberto Busa to produce an index to the works of Saint Thomas Aquinas. The justification of this monumental manipulation of 15 million words lies in Thomas' position as the principal shaper of modern Catholic philosophy, the author of a system widely regarded as the most influential and lasting in the history of Western thought.

Busa began his index before World War II on the traditional handwritten cards, shifted then to punch cards and sorters when they became available, moved on through the generations of computers both in Italy and the United States, and now—on the seven-hundredth anniversary of Thomas' death in 1274—has published the first volumes in pages generated by a computer-driven photocomposer.[1] For future generations of scholars in all corners of the world—to the extent that deeper insight into the thought of this philosopher can be gained by an examination of his vocabulary in rationalized form—this index will serve as a monument to Aquinas, to Busa the disciple who exemplified his belief that faith and reason could independently support each other, and to the wedding of a technological process and a purely humanistic end.

Much smaller in scope and in the time they have taken for execution are the numerous projects to create concordances to almost every conceivable body of literature: Elizabethan sonnets, *The Divine Comedy*, the plays of Eugene O'Neill, the poetry of Robert Frost, the history of Livy, *Paradise Lost*, the cuneiform of Ugarit, the prose of William Blake, and even the as-yet undeciphered writing of the lost civilization of Mohenjo-Daro in the Indus Valley. As crude as some of these concordances have been, they have served already in a number of ways: they have supported various types of analysis that could not otherwise have been performed, they have perfected techniques which are usable in producing future concordances, and they have (at least in recent years) contributed material to future analyses as we sharpen our vision of what the computer can do for us and develop techniques to make those visions reality. On the negative side, we must note that the rapid proliferation of concordances has had the effect of stifling the production of improved works under better technological conditions. Although we now have very good photocomposition capabilities, most libraries will be forced to make do with their current concordances, even when these are semi-legible offsets of computer printout, with no lower-case, often without any punctuation, and in general only a crude approximation of what such a book should and can be. Had we seen far enough into the on-line capacities of the computer, perhaps we should never have produced any of these books in their conventional form, not even the eminently useful concordances to Shakespeare of Marvin

Spevack (new spelling) and Trevor H. Howard-Hill (old spelling). To guarantee the utmost flexibility and the opportunity for each user, every time he consults the data, to structure it in the way most illuminating to him, all these texts should simply have been made machine-readable and supplied—on tape or over wires—whenever and wherever there was an interest in them. But cultural lag is nowhere more prominent than in promotion committees, deans, presidents, and trustees. In their eyes, the preparation of a text seems like secretarial work, but the publication of a book comes within the definition of scholarship. Thus the reflexive drive of the scholar to achieve conventional publication is reinforced by the social and economic pressures of the academic world, and another technological advance is held back by the world's inability to adjust immediately to the new conditions it has created.[2]

The only area where verbal data processing seems to be achieving permanent acceptance and adequate financing is the production of dictionaries. The specialized interests of students of Old English and old Scots are being met by long-term, partially computer-aided dictionary projects now in process. Where national pride generates governmental support—in France, in Italy, in Israel—very real progress can be measured. The acceptance of the computer as a legitimate adjunct of lexicography has reached the point where the editor of a dictionary who has no access to one or who for some other reason does not use one feels called upon to explain his adherence to completely manual methods. Since the value of dictionaries, unlike that of concordances and verbal indexes, is already well established, and since, furthermore, precise definition is at least as important to technology as it is to literary research, it is probably on this front that verbal processing will move forward most rapidly. It is for the production of dictionaries that national institutes are already being established, and the products of these institutes, publicized by the governments whose international reputation is thought to rest on the respect accorded their language, will carry the impression abroad that computers can help man to understand his languages and the works written in them as well, perhaps, as the scientific and social phenomena he is already studying through electronic analysis. In this area, then, we shall probably witness again the venerable battle between the idealists and pragmatists, the seekers of pure knowledge

and the producers of useful objects. In the instance of the new French national dictionary, for example, vast quantities of text were encoded to provide examples for the lexicographers to base their definitions on. I have not yet seen the dictionary, which has begun to appear, but I have been told that all this data is not available for other types of study. In other words, to get their dictionary out in a reasonable time and thereby justify the great investment of capital the government had been persuaded to make, the directors of this project seem to have forgone the possibility of utilizing the same data for further investigations, not only in France but wherever French is studied. This is the sort of problem we must continue to anticipate as work in this area grows in acceptance and perhaps even in glamor. As far as the realities of financing and support will allow, we must reasonably anticipate future needs. We must make every effort to assure that once a text has been made machine-readable, it will be available to every scholar who has a legitimate need for it. Let us assure that every product of a computer-aided study is as perfect in its appearance as the average conventionally printed book. Let all technology—computer, photocomposition, and others yet to come—produce results worthy to stand on the shelves of our libraries next to the works of the predecessor centuries.

In these ways, we can begin to see some of the positive benefits of the new conditions before the phrase "computer-assisted literary research" evokes in every hearer's mind an image of ugly pages, filled with hard-to-read capital letters, and conveying only with difficulty the sense and tone of the original work it is intended to illuminate. The publishers are willing to produce the best books that the computers can be made to emit; the university administrators are authorizing courses specially geared for humanists who wish to learn how the new technology may help them; the only vocal opposition to this development seems based on mere ignorance and reflexive antagonism to progress (one bitter critic, having read that computer time cost $300 per hour, assumed that this was the cost of keeping a data file in any form of memory—even a reel of tape). The balance between those who fear computers, whether that fear grows out of a genuine concern for the future of humanities research or out of shortsightedness and a longing for the familiar, seems to be shifting. With the gradual acceptance of computer-assisted literary research

has come an opportunity to move scholarship a real step ahead, into the twentieth and twenty-first centuries.

Like all historic developments, of whatever magnitude, this evolution will depend on the individuals who, as an aggregate of separate forces, give it shape and direction, thereby changing the techniques and perhaps even the substance of humanities research. At present, we seem to have too few scholars who perfectly blend a deep appreciation of literary values with a high skill in computer applications. Just as in the population at large we find a tendency for individuals to polarize either toward number skills and logic (so that, for example, they enjoy games like bridge and chess) or toward verbal skills (so that their pastimes are crossword puzzles and anagrams), so among the computer-oriented literary scholars there seems to be a group which tends generally toward technique for its own sake and seems to have few original ideas on how to apply it (these often have a mathematics background at some stage of their careers), while another group tends toward applications but with little skill at actual programming. So far, these two groups have limped along in tandem, like the cripple riding the shoulders of the blind man, but as the results have been less than spectacular, we must ensure that the next generation is equally well trained in both ends of this spectrum. As the computer becomes less mysterious, there will be an increasing reluctance to grant kudos to a man simply because he had a bright application and found someone able and willing to do the grubby computer work to get it into a practical form, much less to the technician who worked out a complex package of programs, but only for others to utilize. Within reasonable limits, both the user and the programmer will have to be the same person.

This realization is scarcely new; since the first involvement of literary scholars with computers the dispute over which skill should have priority has occupied many hours of talk and many pages of print. It is, in general, a specious argument, for a literary scholar clearly needs very little of FORTRAN or most of the other programming languages if he is doing truly humanistic research. If anything, too intimate a knowledge of the mathematical possibilities may seduce him away from his proper goals into counting for its own sake. The individuals who argue most for "rigor" in humanities research, even for a new "scientism," turn out usually to be those who have spent

more time in a love-hate syndrome with their programs than in the joys and despairs of literary analysis. Little of their work has concentrated on the subtle, the fragile aspects of verbal art. Having learned that the computer can manage certain objective manipulations, they satisfy themselves only with the objective aspects. The qualities which have kept a literary work alive, perhaps for centuries, are ignored in favor of others which are more amenable to processing techniques. If we have yet to see a major interpretive work issue from the efforts made so far, we need look no further for the cause than this unwinnable conflict between the advocates of programming and those of applications.

The resolution to this impasse lies in neither extremity, but (predictably) in a middle ground. Since none of the extant computer languages was written to handle verbal material *in a humanistic way*, something new is needed. Perhaps the computer manufacturers, finally recognizing the market potential in humanistic computer research, will modify one or more of the extant languages to serve needs beyond those of commerce and technology. Perhaps they will actually produce and support a new language designed for the needs of literary and linguistic research. Neither likelihood, however, is very great. What we can more reasonably expect is that a language like SNAP[3] (probably as extended at the University of East Anglia) will grow in acceptance until it has been improved, simplified, speeded up, and in every way made suitable for our special needs. Like BASIC, this language will be interactive to stimulate new thoughts and responses. It will be easy for non-mathematicians to learn, but powerful enough in its higher levels to permit the rapid and efficient processing of the relatively large data banks customarily required for verbal studies. Its input and output conventions and its subroutines will be suited to the needs of such studies; for example, alphabetizing routines will not push all punctuation to the head of the list but will assign accented words to locations consistent with the practices of each language. Already, parts of such a language are being prepared piecemeal by individual programmers. When they are co-ordinated and when the gaps are filled in, computer-oriented literary research may begin to fulfil the golden promises that have kept so many hopes alive for so long.

A further desideratum is the expansion of opportunities for formal instruction. Although there are now at least several dozen university-level and post-graduate courses in computer techniques or applications for humanistic research available in America, Canada, and Western Europe,[4] the student seeking such instruction is still likely to find that it is not offered on his campus. But administrators and faculty committees are slowly learning that this is not simply a basic skill, like typewriting, but an intellectually substantial learning experience, requiring all that a student can bring to it and sending him away with totally new concepts. Each year, new courses are being added to the roster, thereby encouraging other institutions to avoid cultural lag and offer such a course themselves. Not only individual courses, but also sequences of graduated instruction will ensure that all the potentials of the formal instructional mode will be exploited. And, of course, from these courses will come the next generation of instructors who will expand and sustain the effort to make technology serve the needs of the humanities.

While these new courses are slowly growing, we have had the benefit of several summer institutes. At Pisa, Illinois, and Kansas, groups of scholars have assembled to teach and learn computer techniques in literary and linguistic research. National governments have been relatively generous with faculty stipends, travel allowances, and student fellowships to encourage a good mix of scholars from varied backgrounds. The International Summer School at Pisa has been particularly successful in attracting people from many countries who have stimulated each other and the faculty they have studied under. As other summer institutes are now forming—at Göteborg and Minneapolis—we can anticipate that for the immediate future, these will be an increasingly popular means of helping established scholars to catch up and of training the younger scholars who will follow them.

In addition to formal instruction on as many campuses as can support it and annual summer institutes, there should also be, distributed geographically, a number of centers for advanced research. Probably the best arrangement would be to establish such centers in proximity to other research facilities with powerful computers and a variety of highly trained personnel. Their function should be twofold: to work on fundamental problems and to provide facilities

for selected individuals who are conducting their own research. Experience at such centers already operating at Cambridge and in Bonn should guide those entrusted with organizing new ones, while the lessons learned at the major facilities for new dictionaries—such as those at Edinburgh, Nancy, and Florence—should also be relevant. These centers would also be the logical repositories for the growing data banks of natural language that are being encoded, as well as nodes on any network that is to be established.

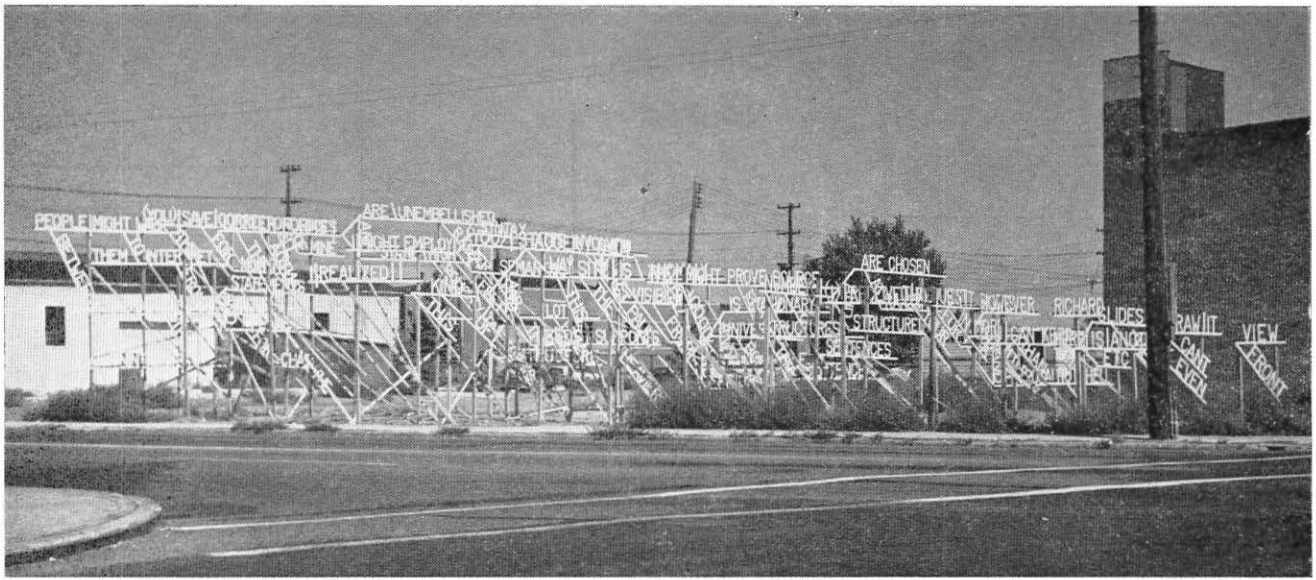
A final concern for the immediate future is computer-assisted instruction. Those who predicted an instant success with machine teaching have learned, like the early enthusiasts of machine translation, that the processes of learning are as complex as those of communication; indeed, they have much in common, especially their refusal to submit to simplistic analysis. Humanists trained to approach subjects which have no readily visible hierarchical structure may already have mastered the philosophy of multi-branched searching techniques that will bring computer-assisted instruction out of the drill-and-practice phase into the broad realm of true learning—that is, self-teaching. If humanists do not involve themselves in this new application, it will, by default, become the province of merely mechanical minds, a means of thrusting information into unwilling students and another triumph for technological impersonality over humanity. If humanists do not concern themselves with directing the future of computer-assisted instruction, they will have themselves to blame when only those factual aspects of a subject which most readily lend themselves to objective presentation drive out the intangible, the nuanced in our approach to humanistic learning.[5]

How these major advances are to grow from the present facilities and personnel is a question that will occupy many of us for some time to come. Without the prestige of scientific or technological research—yet requiring much the same kind of expensive equipment, released time, and support personnel—computer research in the humanities can expect to live under pioneer conditions for perhaps another decade or generation. Until many archaic attitudes have changed, the practitioners of this new art will need to comfort each other with only slowly growing acceptance and support from the larger world of traditional scholarship. But in that long wait for recognition, they

will be able to reach out to colleagues, to exchange information and techniques, sharpen their opinions through the growing number of journals and newsletters devoted to one or more areas of this scholarly field.[6] In the end, they will have developed for themselves and for those who follow them, another means of understanding and responding to the inherited wealth we call the humanities.

1. (Stuttgart: Friedrich Frommann Verlag).
2. For a more detailed discussion of this alternative, see my article "The Death of the Handmade Concordance," *Scholarly Publishing*, I (October 1969), 61–69.
3. Described in Michael P. Barnett, *Computer Programming in English* (New York: Harcourt, Brace & World, 1969).
4. For listings of such courses, see Edmund A. Bowles, "Towards a Computer Curriculum for the Humanities," *Computers and the Humanities*, VI (September 1971), 35–38; Leila de Campo, "Computer Courses for the Humanist: A Survey," ibid. (September 1972), 57–62.
5. For the most recent survey of computer-assisted instruction in the humanities, with an extensive bibliography, see John R. Allen, "Current Trends in Computer-Assisted Instruction," *Computers and the Humanities*, VII (September 1972), 47–55.
6. Current activities in computer-aided humanities research are reported regularly in *Computers and the Humanities* (1966–date); a comprehensive annual bibliography is published every spring.

This article has been reprinted with kind permission from the inaugural issue of the *ALLC Bulletin* of the Association for Literary and Linguistic Computing; Professor R. A. Wisbey, Chairman (Department of German, University of London, King's College, London WC2R 2LS).



Sentence Structures was created by Robert Cumming (227 South Shaffer, Orange, Calif. 92666) and constructed with the cooperation of Richard Koshalek on a vacant lot in St. Paul, Minnesota. Mr. Cumming has commented: "From the letters I had written describing the idea of *Sentence Structures*, I selected about twenty sentences of varying lengths and complexities. The lot I selected was wedge-shaped, so I staggered the individual structures from the simplest back to the most complex at the widest portion of the lot. I cut the letters from $\frac{5}{8}$ inch plywood using a standard one foot high gothic stencil so they could be spray-painted onto the plywood and cut out. There were about 1,200 letters (150 letter E's), which were spray-painted a bright yellow. I made blueprints of each of the structures since a construction firm had to install them. I knew in advance that from a distance the twenty or more structures would overlap and be unintelligible. To sort out the meanings, a person would have to walk among the structures to unscramble them. Then the structures would reveal the thinking that created them. . . ." Photograph: Eric Sutherland. Walker Art Center.

Excerpt: Which Computer Printer When?

Larry Lettieri

In our paper-oriented society the computer printer has become an indispensable part of the data processing operation, since it supplies human-readable copy of computer information.

Today's impact printers are characterized by minimal mechanical complexity. In the place of sliding friction devices like clutches and brakes, electronically controlled drives use ball bearings and reliable stepping motors. Similarly, hammer mechanisms using only leaf springs and magnets are replacing the large number of moving parts in earlier designs.

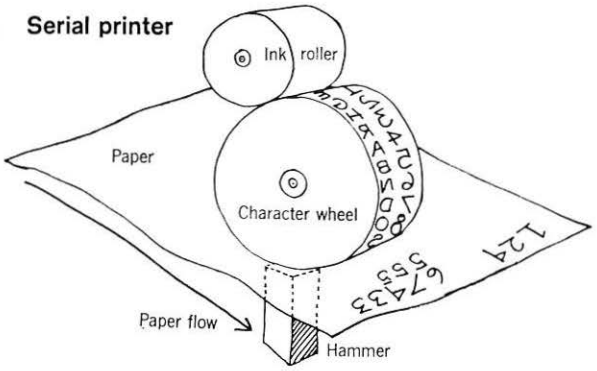
The demands for speed, reliability, and simplicity have to some extent been answered by the development of nonimpact printers. Using electronic or chemical processes, nonimpact devices are quieter, faster, and more reliable than the conventional impact printer. Their versatility allows them to fit needs at both the high- and low-speed ends of the product spectrum making them suitable for many applications. Print speeds of up to 5000 lines per minute are not uncommon, the only barrier to increased speed being paper transport mechanisms. These machines can produce only one copy at a time, however, and require users to rethink their entire paper flow system.

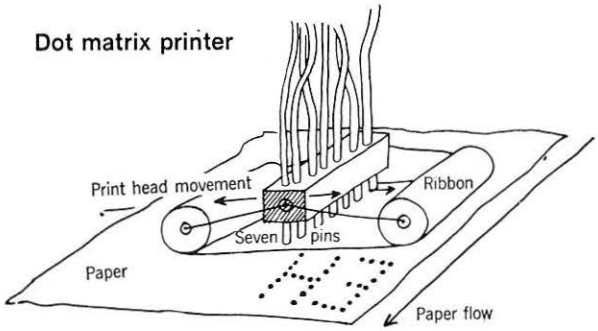
Techniques Affect Speeds

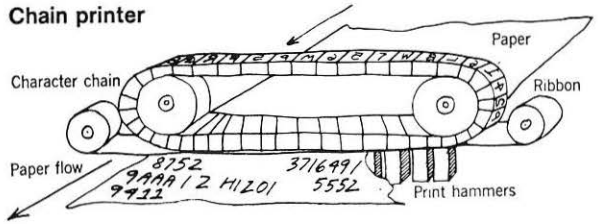
The impact printer remains the most popular type of printer on the market. These devices are capable of extended operation, offer easy maintenance, and are dependable. An overview of the types of printing mechanisms in use provides some insight into printer performance and operation.

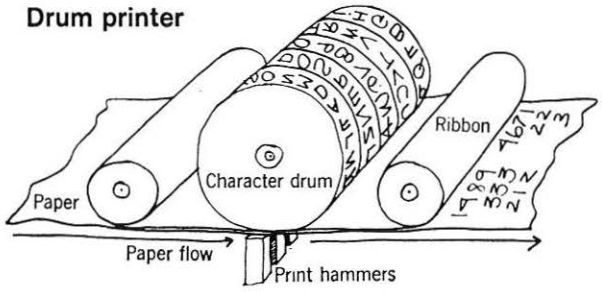
Visible Language, VIII 2 (Spring 1974), 179–185.

Author's address: *Computer Decisions*, 50 Essex Street, Rochelle Park, N.J. 07662.


Serial printer
Ink roller
Paper
Character wheel
Paper flow
Hammer


Dot matrix printer
Print head movement
Ribbon
Seven pins
Paper
Paper flow


Chain printer
Paper
Character chain
Ribbon
Paper flow
Print hammers


Drum printer
Ribbon
Character drum
Paper
Paper flow
Print hammers

A continuous motion serial impact printer prints one character at a time. The print wheel, whose surface is covered with raised characters, is spun continuously. The printer makes typewriter-like impressions by having a print hammer drive the paper against the wheel and the selected character as the character moves into position. The process is repeated for each column across the page, one character being printed for every revolution of the print-wheel. This process is frequently termed "printing-on-the-fly".

Full character serial impact printers have had an inherent speed limitation of 25 to 35 characters per second. However, one manufacturer has been able to overcome this limitation by placing three character sets on the print-wheel. This allows the mechanism to print up to three characters for each revolution of the print wheel. Using this approach the printer has been able to reach speeds of 100 characters per second.

The need to overcome the speed barrier for character printers, while not increasing cost or mechanical complexity, has led some manufacturers to develop dot matrix printers. The dot matrix printer creates characters by building up a 5×7 (or 7×9) array of dots using solenoid-driven pins. In the case of the 5×7 dot matrix pattern, printing is achieved by moving the print head containing the seven pins across the page. The pins are actuated at five successive intervals to form the character. For example, to print the letter "H" all seven pins are fired to create the first vertical pattern. The print head then moves to the right and the middle pin is fired three times to generate the horizontal portion of the character. All seven pins are then actuated again to produce the second vertical portion.

Using the dot matrix technique, character printers have been able to achieve higher speeds than a full character printer. One such printer, which utilizes a 7×9 matrix, is able to print 330 characters per second, or about 125 lines per minute. There are some drawbacks, however, to the dot matrix technique. Though the printer contains few moving parts, the pins are subject to wear since several impacts per pin are required to generate each character.

Faster, though more costly than character printers, line impact

Figure 1. Techniques employed by impact printers.

printers print one full line of information at a time and are capable of printing more than 2000 lines per minute. These high-speed line printers are usually considered the most versatile and dependable and are compatible with the most severe applications. There are two basic types of line printers: the drum printer and the chain or train printer.

A drum printer is somewhat similar to a serial character printer. In place of a single, narrow character wheel printing one character at a time, the drum spans the width of the paper. Each position on the drum has a complete character set so that a character is positioned in each column with every revolution of the drum.

Chain and train printers use character sets that are mounted on what might be called belts. The character set passes in front of a row of print hammers that strike the appropriate character as it passes the column. The difference between a chain and a train printer is that with the former the characters are mechanically linked, while in the latter each character rides around a track freely. Train printers enable the user to change the character set easily.

Sounds of Silence

Nonimpact printers use various electronic and chemical techniques to create images of the characters on paper and to achieve higher speeds. Because images are formed by dots or points rather than solid lines, these printers can also be used with suitable software to function as plotters to create pie charts, line or bar graphs, or more complex graphics. The techniques currently in use are:

Electrostatic. This method consists of imprinting an electrostatic pattern on dielectric paper by means of charged wires or pins. The pins supply a charge to the paper in the desired pattern. The characters become visible as the paper passes through a solution containing ink particles of opposite charge to the paper, which adhere to the charged spots on the paper.

Magnetic. This process imprints magnetically charged particles from a belt onto paper. The characters are written onto the belt in much the same way that a magnetic tape recorder operates. The belt is exposed to a toner composed of colored particles in liquid suspension. The ink particles in the toner adhere to the belt in the

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THE 101A HAS A PRINTING SPEED OF 165
CHARACTERS PER SECOND.  LINE PRINTING
RATES VARY FROM OVER  200  LPM ON
SHORT LINES TO APPROXIMATELY 60 LPM
ON FULL 132 CHARACTER LINES.

■¤m ℓtöØüÅ³ §¹² ℔±£<>○7¼℞½¾℞ÆÅÑ¢ ǂΓΔΘ

 !"#$%&'()*+,-./0123456789:;<=>?

ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^←
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Figure 2. Printout from a dot matrix printer; below, enlarged detail.

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WHICHEVER
IS IN THE
EVEN IF Y
SENTED, I
HAS FOUND
```

appropriate pattern. The belt is placed in contact with the paper, and then the paper is heated to fuse the characters to the page.

Thermal. Thermal devices use printheads that convert electrical pulses to heat. The image is created on heat-sensitive paper. These printers are slower than electrostatic or magnetic printers due to heating and cooling requirements. If the heads don't cool properly between characters, "ghosts" result.

Ink Jet. This technique shoots a stream of charged ink drops toward the paper. The stream is deflected by electrostatic plates to sweep out an image of the desired character. The charged particles adhere to the paper to create a line of print. Ink-jet printers require special paper to catch and hold the charged ink.

Despite the complaints that nonimpact printers cannot provide multiple copies, require special paper, and frequently use less-readable fonts, they do offer both minicomputer user and large system user certain advantages. For the minisystem user, whose computer often costs less than $5000, the nonimpact printer offers, for a price that is compatible with his budget, a high-speed alphanumeric printer and a high-speed plotter for graphics applications. The large-scale system user can get a faster, more reliable plotter in a nonimpact device, one that can be several hundred times faster than a drum-type plotter. The resolution of electrostatic plotters is lower than that of pen-type devices, but ample for business uses.

As the cost for special paper drops—it is about 1.3¢ per sheet for an electrostatic printer and still dropping—the plusses of nonimpact devices become more meaningful to all users. The combined printing/plotting ability of many can reduce equipment costs. High speed cuts throughput time: the only thing keeping speed down is paper movement—the only mechanical portion of the devices. They are quiet in operation making them suitable for office environments. And because they have few mechanical parts, they are reliable—3000 hours or more between failures is not uncommon.

This article has been excerpted with kind permission from "Which Printer When," *Computer Decisions*, August 1973.

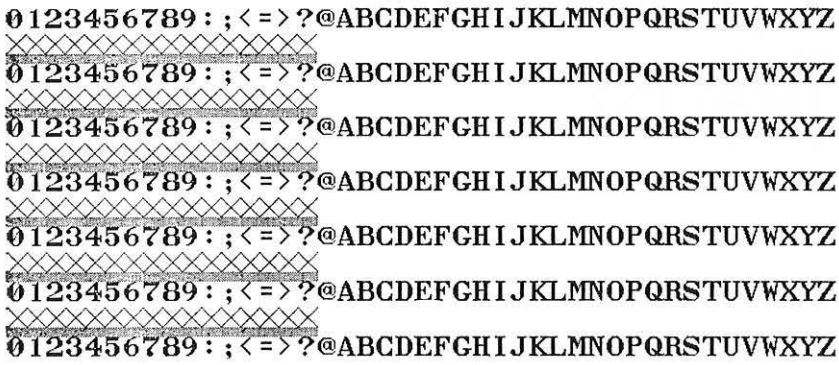
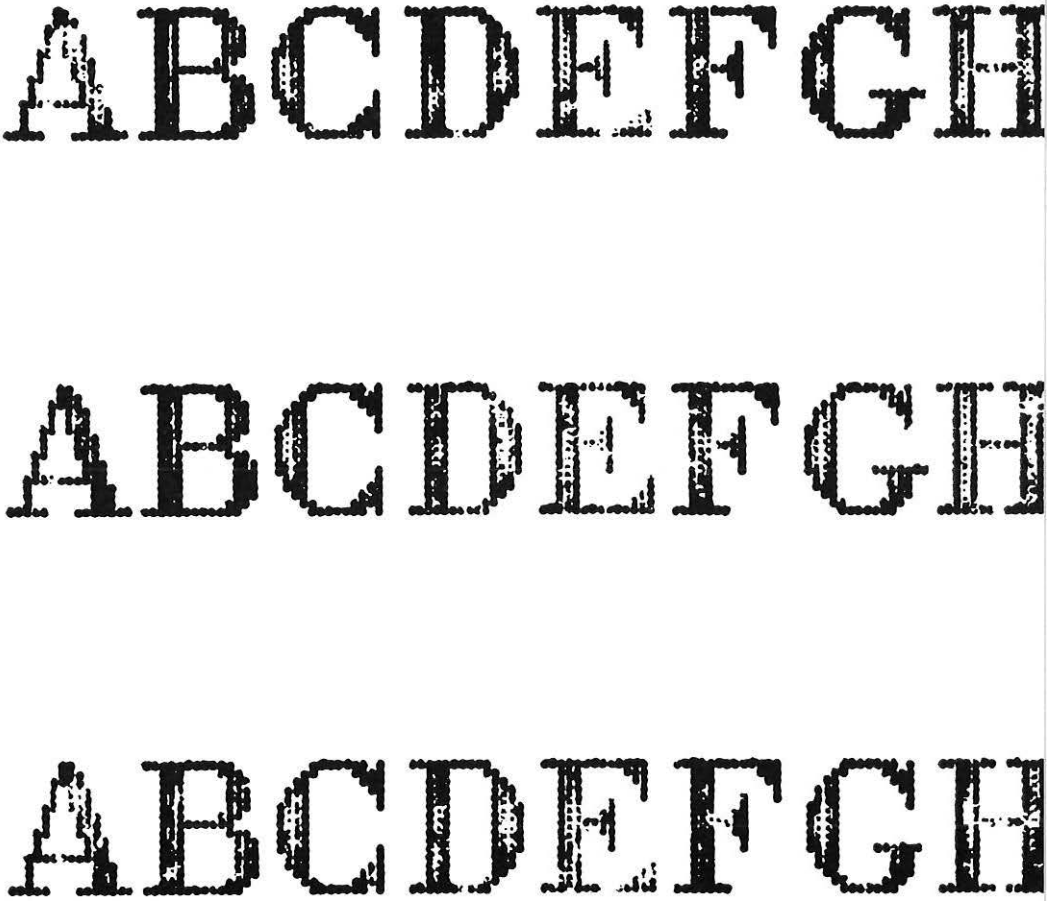
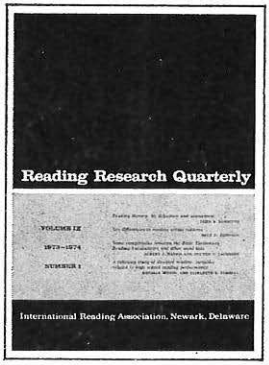


Figure 3. Printout from noimpact printer; below, enlarged detail.





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Book Review

Ruari McLean. *Victorian Book Design and Colour Printing*. London: Faber & Faber, 1973. £15.

First published in 1963, this edition is very much expanded. It contains new material that became evident through Ruari McLean's recent research into the work of the engraver Edmund Evans. McLean claims with justification that more exciting things happened in book design between 1837 and 1890 than in any comparable period in printing history—most of them happened in London.

During this time new urban conditions spawned a population bulge; a society with new needs from books: larger editions of almost everything, and school books, children's, natural history, popular science, and religious books—all in revolutionary formats. Then came the circulating and "railway pocket libraries," the "three decker" novel, the *Penny Cyclopedia*, and the "shilling monthly part book." There was the first appearance also of another contemporary phenomena: the coffee table art book; one of them in those Victorian times actually did have brass "feet" to stand on. However, these heavily illustrated chronolithographed productions did introduce Islamic and Hindu art to Europe—sometimes in 20 colors and gold.

A curious by-product of technical advances in color printing at that time was the supply of a number of how-to-do-it samplers on medieval illumination. The year 1820 saw the innovation of bookbinding cloth—and much else: books cased in velvet, silk led onto porcelain, tortoise shell, enamel and gilt, and sepulchral embossed black papier-mâché. Few craftsmen remained masters of the new situation, but Whittingham and Pickering continued to print both text and illustration on hand-made paper without the benefit of the steam engine.

The interests in this period of illustration are technology and social history; to my mind art is not much in evidence, although McLean makes a case to dispute this. What characterizes the Victorian book for me is emasculated artwork overladen by an over indulgence of maudlin senti-

ment; fretted, fussy, and overworked ornamentation, and unthinking mixtures of style. There are few heroes in the book who escape this and many who win their place not through art but through craftsmanship.

In an era of quick fortunes and frequent bankruptcy, the high cost of books for circulating libraries was constantly under fire from the Society for the Promotion of Useful Knowledge. They published their own books, and unlike Ruskin believed that cheap literature would do good to mankind; they were supported by other publishers who were sure that cheaper books would do good to themselves.

Ruari McLean has written a book of great scholarship—well documented and indexed and very attractive—but at £15 the nineteenth-century philanthropists would not approve!

Colin Banks

Colin Banks is a partner in the London design group Banks and Miles. As well as being a practising graphic designer he is an active campaigner in design education and information. He recently returned from lecturing on Western letter forms in Japan to organize a conference on "Design and Change" for the Society of Industrial Artists and Designers.

Résumé des Articles

Traduction: Fernand Baudin

Le rapport lecture-orthographe-phonétique, *par Robert A. Barganz*

L'auteur a étudié les effets d'une orthographe basée sur la grammaire des transformations. Le but était de savoir dans quelle mesure les bons et les mauvais élèves de cinquième ont recours à des correspondants sémantiques lorsqu'ils rencontrent des éléments orthographiques étrangers à la phonétique. Un schéma $2 \times 2 \times 4$ servit à apprécier la capacité de lecture (bonne ou mauvaise) le degré d'abstraction des termes (concrets ou non) et la nature des stimuli et des réflexes (oralement et par écrit). Les performances des bons et des mauvais lecteurs différaient sensiblement ($p. < .0005$) lorsque les exercices portaient sur la perception de correspondances en profondeur. Ces différences s'atténuent dès que les correspondances sont perceptibles par une lecture superficielle. Les bons lecteurs renoncent apparemment au niveau de lecture élémentaire au profit d'une technique qui ignore les liens graphême-phonème mais qui s'attache plutôt aux correspondants sémantiques.

Technologie de la lecture et politique culturelle, *par John R. Bormuth*

Les moyens de préparer et de favoriser la compréhension de la prose imprimée ont fait du chemin et sont passés du domaine artistique au niveau scientifique. Ils constituent même une technologie susceptible d'un très large degré de généralisation et d'une grande précision. Il est particulièrement intéressant de noter les ressources que présente ce corps de doctrine pour aider les états à élever leurs populations à un degré convenable de culture littéraire tout en réduisant le coût matériel de l'opération. L'article souligne les raisons d'intensifier cette technologie dans les pays industrialisés et de l'introduire dans les pays en voie de développement.

Inscriptions américaines anciennes, *par Francis Duval et Ivan Rigby*

Une série de reproductions de pierres tombales américaines des XVIIe et XVIIIe siècles, précédée d'une introduction concernant leur technique, leur présentation et d'un plaidoyer en faveur de la conservation de ces témoins historiques du folklore américain.

Une bibliographie de la lecture optique. Comment décrire les caractères, *par R. Shillman, C. Cox, T. Kuklinski, J. Ventura, M. Eden, B. Blesser*

Bon nombre de références se rapportent aux domaines des ingénieurs et des psychologues et à la manière de décrire les caractères composés manuellement aussi bien que mécaniquement.

L'humaniste et l'ordinateur, *par Joseph Raben*

Jusqu'ici l'utilisation des ordinateurs pour l'étude des humanités n'a rien donné de plus qu'un relevé systématique des sujets traités. Les questions d'input et d'output, de traitements des données, de nouvelles méthodes non numériques qui occupent les théoriciens n'ont fait que reculer ce que l'on avait imaginé comme un bond en avant dans la critique des travaux des humanistes. Les résultats les plus substantiels obtenus à ce jour consistent en listes de mots (lexiques, index, concordances). Il est évident que des capacités de triage ultra-rapide, sans fatigue et sans erreur ont considérablement accéléré la production de ce genre d'outils de l'érudition. Un nouveau type d'historien de l'humanisme est en voie de formation, très cultivé dans sa branche mais aussi parfaitement au courant de tous les aspects de l'informatique qui ont un rapport réel et direct avec l'objet de ses études. Il contribuera à la création de nouveaux languages pour la programmation de ce qui l'intéresse, à la formation de ses successeurs et à faire sortir l'informatique de son ornière mécanique.

Kurzfassungen der Beiträge

Übersetzung: Dirk Wendt

Phonologische und orthographische Beziehungen zur Leseleistung *von Robert A. Barganz*

In dieser Arbeit wurde die Wirkung eines zwischengeschalteten Niveaus orthographischer Darstellung untersucht, das auf der theoretischen Grundlage einer generativen Transformationsgrammatik aufbaute. Allgemeines Ziel war es, festzustellen, ob ein System semantischer Entsprechungen benutzt wurde, wenn gute und schlechte Leser aus fünften Klassen mit phonetisch irrelevanten Eigenarten der Orthographie zu tun bekamen. In einem $2 \times 2 \times 4$—faktoriellen Versuchsplan wurden die Wirkungen von Leseleistung (gut vs. schlecht), Umweltrealität (wirklich vs. pseudo) und Art der Darbietung der Reize und Reaktionen (mündlich vs. schriftlich) untersucht. Gute Leser zeigten statistisch signifikant ($p < .0005$) bessere Leistungen als schlechte Leser in solchen Aufgaben, wo es auf das Erkennen von Regelhaftigkeiten auf einem tieferliegenden Niveau ankam. Diese Unterschiede verschwanden, wenn die Regelhaftigkeiten auf einem mehr oberflächlichen Niveau erkannt wurden. Gute Leser schienen eine Suchtechnik zu zeigen, bei der ein einfacheres Entsprechungsniveau zugunsten eines effektiveren verlassen wurde, auf dem Graphem/Phonem-Entsprechungen zugunsten semantischer Entsprechungen aufgegeben wurden.

Die Verbreitung des Lesens und die Entwicklung der Lesbarkeits-Technologie *von John R. Bormuth*

Die Verfahren zur Vorhersage und Veränderung der Verständlichkeit gedruckter Prosa sind ständig fortgeschritten, vom Status einer Kunst über den einer Halbwissenschaft, und entwickeln sich jetzt zur wissenschaftlichen Technologie mit beträchtlichem Allgemeinheits- und Genauigkeitsgrad. Besonders interessant ist die Tatsache, daß dieses Wissen ein erhebliches Potential für die Wirksamkeit der Anstrengungen einer Nation darstellt, in der Bevölkerung eine erwünschte Verbreitung der Lesefähigkeit zu erreichen und dabei gleichzeitig die Kosten für diese Anstrengungen zu reduzieren. Dieser Aufsatz umreißt einige der Argumente für die Beschleunigung der Entwicklung dieser Technologie in den entwickelten Ländern und den Aufbau dieser Technologie in den Muttersprachen der Entwicklungsländer.

Inschriften aus unserer Vergangenheit *von Francis Duval und Ivan Rigby*

Eine Auswahl von Inschriften amerikanischer Grabsteine aus dem 17. und 18. Jahrhundert wird demonstriert. Eine kurze Einführung handelt von der dringenden Notwendigkeit, diese aufzuzeichnen, ehe ihr Verfall weiter fortschreitet.

Eine Bibliographie zur Zeichen-Erkennung: Technicken zur Beschreibung von Zeichen *von R. Shillman, C. Cox, T. Kuklinski, J. Ventura, M. Eden, B. Blesser*

Es wird eine Bibliographie für das Gebiet der Zeichen- (Ziffern und Buchstaben-) Erkennung vorgelegt. Viele der Literaturangaben sind aus dem Bereich der Ingenieurwissenschaften und Psychologie und handeln von verschiedenen Techniken zur Beschreibung von maschinen- und hand-erzeugten Druckschriften.

Der Humanist im Computer-Labor
von Joseph Raben

Die bisherigen Versuche zur Anwendung von Computern in den Humanwissenschaften haben mehr zu einer grundlegenden Analyse des Themengebietes selbst als zu bedeutsamen Ergebnissen geführt. Die Probleme der Eingabe und Ausgabe, der Entscheidung über die Anwendung passender Verfahren, und der Entwicklung neuer Verfahren, die sich nicht aus den üblichen numerischen Ansätzen ableiten, die gegenwärtig das Computer= Denken dominieren—sie alle haben verzögert, was als dramatischer Fortschritt in Richtung auf eine neue Art humanistischer Kritik erwartet wurde. Die bislang wesentlichsten Errungenschaften waren die rationalsierten Listen von Wörtern (Wörterbücher, Sachverzeichnisse, Konkordanzen), bei denen die Fähigkeit des Computers, schnell und ohne Ermüdung oder Fehler zu sortieren, die Produktion solcher herkömmlicher Hilfsmittel der Gelehrsamkeit beschleunigt hat. Ein neurer Typ Geisteswissenschaftler, der jetzt entsteht —hoch spezialisiert und ausgebildet sowohl in den Humanwissenschaften, und gleichzeitig in den Teilgebieten der Computer-Wissenschaft, die echt bedeutsam für seine Untersuchungen sind—wird beitragen zur Erstellung neuer Programmiersprachen, die speziell für diese Arbeit konzipiert sind, und in der Ausbildung anderer mithelfen, die ihm nachfolgen, und die von Computern gesteuerte Instruktion über das gegenwärtige mechanistische Niveau hinausheben.

This number of *Visible Language* has been composed in "Monotype" Baskerville type and produced by W & J Mackay Limited, Chatham, England, on Beaublade Nimrod Cartridge, 100gm². The layout is based on the original design by Jack Stauffacher of the Greenwood Press, San Francisco.

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