Some psycholinguistic considerations in practical orthography design

by Raymond G. Gordon

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Practical orthography design is the development of a system of arbitrary visual symbols to be used by speakers of the language for which it is designed. The process assumes a relationship between language and writing. This relationship may be defined in a number of ways, dependent on the language features that the orthography encodes. In this article, I attempt to describe some of these ways and show that the view, that writing encodes speech, tends to restrict this relationship between language and writing to phonological features. I argue that an approach to orthography design, based on this view, imposes unnecessary restrictions in the ways in which symbols may encode features of a language.

1. Encoding relations

Theoretically, we can view encoding relations from two extremes. On the one extreme, the only requirement of an orthography might be that it encode meaningful forms in an unambiguous way. That is, each distinct linguistic form must look different in its graphic representation from all other forms of the language. This difference is stated without regard to the nature of the symbols themselves, whether romanized character, rebus, or any other type of visual symbol. Such a system would admit no

homographs; there would be no lexical ambiguity. English *while* (the conjunction, as in *while we were eating)* and *while* (the verb, as in *while away the hours)* would have to be written differently.

On the other extreme, orthographies might be required to represent forms in a patterned way, isomorphic with the phonological patterning of oral speech. Graphic forms, in these instances, might even be regarded as sets of symbolic articulators instructions for producing oral forms from visual ones. In such a system, all homophones in the spoken form would be carried over as homographs in the written form, allowing a degree of lexical ambiguity: English *pear* and *pair* would have to be spelled the same as would French *eau* and *au* and *haut.*

Actual writing systems, which approach the first requirements, are called morphemic or logographic or ideographic. They tend to encode morphemes or words without reference to their sound. Systems complying with the second requirement may be called phonetic (for which actual coding is of phones, without regard to their linguistic relationships) or phonemic (for which actual coding is of phonemes or of syllables taken as entities defined in a linguistic system).

Somewhere between these two extremes lie morphophonemic orthographies. The requirement for such an orthography is that it symbolize phonological segments in such a way that each morpheme is represented in a way that minimizes change under contextually dependent phonemic variation, just as a phonemic orthography represents phonemes as invariants under phonetic contextual variation. From the standpoint of generative grammar, for example, a morphophonemic system might symbolize the systematic segments of underlying lexical representations. Chomsky and Halle have noted that English orthography is highly consistent with a systematic phoneme representation and comes "remarkably close to being an optimal orthographic system for English" (Chomsky and Halle 1968:49). The psycholinguistic question of the extent to which speakers possess and can utilize their intuitive knowledge of language rules in dealing with practical orthography, however, is yet to be answered.

Phonemic orthographies overdifferentiate in the way they represent morphemes, in the sense that some morphemes may have more than one graphic shape. A phonemic spelling of English plurals would include *z* (dog*z)* as well as *s* (cat*s)*. Morphophonemic orthographies, on the other hand, underdifferentiate systematically in the way they represent phonemes, in that some symbols may represent more than one phoneme. The English plural *s* represents both the /s/ phoneme and the /z/ phoneme.

These three systems of representation, the morphemic, morphophonemic, and phonemic, thus, differ in three aspects of encoding:

1. Maximal distinction of forms (in the sense that each language form has a unique graphic form)

2. Consistency of morpheme shape

3. Phonemic regularity

Morphemic systems offer maximal distinction of forms and consistency of morpheme shape, but for some languages, such as those in the Algonquian family, morphemic writing would obscure the phonemic shape of a large portion of written forms, in that conditioning processes that tend to produce morpheme variants are pervasive. Phonemic systems offer phonemic regularity, but compromise maximal distinction

of forms and consistency of morpheme shape. Morphophonemic systems, which contain features of both of the other systems, offer consistency of morpheme shape along with a relatively high degree of phonemic regularity. At the same time, however, they provide no guarantee of maximal distinction of forms, in that distinctions that may be gained through distinguishing homophones at some points in the language (that is, *herd* versus *heard*) may be offset by generating homographs at other points (that is, *moped*, past tense of the verb *mope* or a type of motorized bicycle).

1.1. Practical encoding options

American linguists, who early addressed the problems of orthography design, generally favored phonemically oriented systems (Pike 1947; Nida 1947, 1954; Hockett 1958; Smalley 1959). In recent years, alternative approaches to orthography have been put forward (Chomsky and Halle 1968; Halle 1969; Chomsky 1970; Klima 1972). As a result, recent attention has been given to the relative merits of the phonemic versus the morphemic systems.

The phonemic position assumes that independent word identification is possible, once the sound-symbol relations are learned. If a reader knows the sound-symbol relations and can pronounce a form, he is assumed to be able to read it. But, this assumption is not always supported by experience with new readers. Gudschinsky (1958) offers an example of evidence that reading involves more than recovering the phonemic values of the symbols. She reports that Mazatec readers find difficulty in reading phonemic tone marks when morphophonemic conditioning takes place across word boundaries. At the same time, she found that reading of tone took place readily when the conditioning across word boundaries was ignored in the orthography, so that the tones were written consistently on the word.

Morphemic systems require a symbol for every morpheme in the language, perhaps 50,000 or more. It is commonly argued that memorization of such numbers of characters, as in Chinese, requires an effort of many years to achieve a recognition of a fraction of the total (Nida 1947; Jones 1950; Brown 1958; Goody 1968; Hockett 1958; Powlison 1968; Halle 1969; Klima 1972).

The learning difficulties associated with morphemic systems, however, may not be as severe as is at first apparent. Downing (1973b) points out that morphemic systems are not well understood and that difficulties are often exaggerated. For example, even though Halle asserts that learning to read Chinese "is roughly equivalent to memorizing several thousand telephone numbers …" (Halle 1969:18), there is no clear evidence to show that learning to read Chinese characters and memorizing telephone numbers are analogous tasks, even though, in practice, they may be approached in the same way. Research now shows that recognition of graphic words does not depend exclusively on an ability to recognize them in isolation in a way that telephone numbers usually are. In fact, both syntactic (Kolers 1970; Levin and Kaplan 1970; Weber 1970) and semantic (Meyer and Schvaneveldt 1971; Meyer 1974) environments enhance word recognition enough that assumptions about the memory load for learning Chinese characters are seen to have generally been overstated.

Furthermore, Alleton (1970) suggests that only a small subset, 1,000 characters, suffices for 90 percent of reading in Chinese and that 90 percent of all characters are phonetic compounds (cited by Martin 1972).

At the same time, the learning task for English has often been underestimated, in that, although there are but 26 characters, the total set of sound-symbol relations is much larger (Venezky 1970). This fact, coupled with the existence of forms that are encoded morphemically, to varying degrees removed from phonological correspondences (Bolinger 1946), diminishes the force of the argument of contrast between logographic and alphabetic systems, especially in the specific examples of Chinese versus English. A final argument in favor of morphemic systems is that they can handle wide variations in dialect (Smith 1971; Martin 1972; Downing 1973a; Leong 1973).

It may be that efficiency is a minor factor in distinguishing the learnability of morphemic versus phonemic systems. It has yet to be shown that there are essential differences in the way readers deal with these systems. It has been argued that observed differences may be largely due to pedagogical approach and not to the writing systems themselves and that, given the appropriate pedagogical approach to each, no real differences would obtain (Feitelson 1967). Gibson and Levin (1975). Gibson and Levin (1975) observe that readers may adapt to the system and learn to capitalize on the strengths of the system they are learning, but admit that research is inconclusive and inadequate. This conclusion is supported by Brimer:

> … the freedom of individual characters from ambiguity of phonemic reference does not imply a more efficient orthography. Whether or not the more economic orthography yields the more efficient reading is one of the research questions that remains unanswered.

This debate about the practicality of phonemic systems versus morphemic systems appears to be based on other unsettled issues in the field. The first concerns the nature of the reading process; essentially, what is the role of phonology in reading? If it is central, phonemic systems ought to show a clear advantage. If, on the other hand, reading is primarily a visual task, not phonologically dependent and dealing more directly with syntax and semantics, the difference should be obscured. Since evidence supports both positions, resolution awaits a clearer understanding of the nature of the task or differences between experimental tasks and nonexperimental reading.

A second issue is the distinction between beginners and literates. Gillooly points out that phonemic systems better serve beginners in that "all that must be learned in order for a child to read a strictly phonographic writing system is a discrete number of symbol-sound associations …" (Gillooly 1973:191). Downing (1973b), on the other hand, suggests that morphemic systems may be more appropriate for beginners and that phonemic systems better serve adults. This suggestion is based on the fact that beginning readers respond more readily to meaning elements than to phonological elements and that a response to phonological elements assumes a level of phonological awareness that is not easily achieved.

A third issue concerns the differences between the task requirements of reading as opposed to writing. Are demands on the speller more severe with morphemic systems? To what extent does the nature of the spelling task differ across systems?

A final issue concerns the number of characters and the nature of learning involved. Does the size of the character set relate to learnability? Do smaller character sets offer a distinct advantage? When these

empirical issues are more clearly resolved, the matter of the comparative practicality between these systems should, likewise, become clearer.

2. Speech and writing

As was stated earlier, orthography design is usually based on an assumed encoding relation between speech, writing, and language. This relation is defined by the way in which the function of writing is perceived. I will discuss two of the various ways that writing has been viewed, in relation to speech, to clarify the position taken here.

The first is that the function of writing is to represent speech. The second is that writing is independent of speech and that both speech and writing function as distinct expressions of language.

3. Writing represents speech

The view that written language is derived from spoken language has dominated nearly all discussion of practical orthography.

This view can be seen to underlie the work of those who were among the first to design practical writing systems for languages that had not previously been written. During this early period, effort was directed toward producing a standardized alphabet that would suffice for at least a large segment of the world's languages.

Sir William Jones (1788) was the first to express this concern in his work toward a uniform system for representing the Indian, Arabian, and Russian languages. A similar effort was put forth by Pickering who, in 1820, proposed a standard orthography for use in North American languages. This direction was continued by Lepsius in 1855. His work was primarily directed toward the languages of Africa. Lepsius took up the task of assigning symbols to all of the sounds used in the world's languages. It was supposed that readers of indigenous languages could then have access to any language through the knowledge of the sound-symbol relations that were learned in the process of learning to read their own language (Grout 1859).

The mid-nineteenth century marked a notable increase in missionary activity in Africa and, in a short period, dozens of writing systems came into use, often more than one per language where more than one missionary society was established (Lepsius 1855:40).

Early efforts at practical orthography failed to distinguish "scientific" linguistic orthography from the "practical." Problems in designing and teaching these orthographies led linguists to recognize three distinct applications of orthography: First, linguists wanted a standardized system which could be used for comparative studies across languages. Second, outsiders, such as missionaries, needed a notation to help them learn a language, and third, native speakers needed a notation for learning to read and write their own language. Discussion centered on the need or the lack of need to produce different orthographies for different purposes (Grout 1859). Some linguists argued that native readers require less symbolization than outsiders (Holmboe 1855). While, in general, this was proven true, in practice, there were no guiding principles by which encoding could be reduced. Over time, orthographies in some parts of Africa

diverged more and more from the "scientific" or strictly phonemic, usually by failing to mark suprasegmental phonemes or other features often marked by diacritics (Nida 1957:131and Welmers 1971:569), and fairly often with unfortunate results (Nida 1947:110), but the underlying encoding assumptions remained the same—the symbolic relations that were expressed were essentially phonemic.

Likewise, in America, the view that writing represents speech was pervasive among linguists as these selected remarks show:

> … writing is, except for certain matters of detail, merely an external device, like the use of the phonograph, which happens to preserve for our observation some features of the speech of past times (Bloomfield 1933) writing is, except for certain matters of detail, merely an external device, like the use of the phonograph, which happens to preserve for our observation some features of the speech of past times (Bloomfield 1933:282).

> Writing is essentially a way of representing speech, almost always an imperfect and inaccurate way …. Writing is a derivative of speech (Hall 1950 31, 35).

> A written language is basically a representation of a spoken language. It is, however, very seldom an exact reflection (Gleason 1961:425).

> Writing does represent speech, but there is a range of flexibility and variety by which different writing traditions and different stylistic usages in different languages represent speech to different degrees (Smalley 1964b:4).

Although not explicit in its formulation, the "writing represents speech" assumption generally appears coupled to the psychological claim that an ideal practical orthography is a strict encoding of phonemes. This position has been expressed in these ways:

> A practical orthography should be phonemic. There should be a one-to-one correspondence between each phoneme and the symbolization of that phoneme …. the goal of learning to read rapidly and easily is achieved by making a conscious or unconscious association between sound and symbol (Pike 1947:208–209).

> The theoretically perfect goal of a system of writing would consist in representing each phoneme with only one symbol, writing just as people speak (Nida 1954:37).

> In a *phonemic writing system*, graphic shapes are assigned, in an arbitrary fashion, not to the morphemes of the language, but to the phonemes or to some sort of recurrent combinations of phonemes (say, syllables). Fewer graphic shapes are needed and such a writing system is consequently learned much more quickly (Hockett 1958:540).

> It seems clear that a writing system which represents the phonemic level (whether on a syllabic or alphabetic basis) is the most efficient basic system, because it requires the learning of the fewest symbols to represent the full range of speech (Smalley 1964b:7).

It should be added, in fairness to the above writers, that all of them have recognized the need to deviate from this controlling principle and, since the date of these writings, more types and greater degrees of deviation have been suggested. But, the fact that these deviations from a phoneme-based design are viewed as "exceptions to the rule" supports the claim that the "writing represents speech" position actually underlies most current approaches to the design of orthographies.

Venezky (1970) recognizes three implicit, but generally unstated, assumptions that underlie a phonemic approach to orthography:

1. That the reading process involves little more than producing sounds from symbolic stimuli.
2. That human language processing is isomorphic to the descriptions of language which structural linguists produce; that is, proceeds from one discrete level to the next in the order of phonology, morphology, syntax, and semantics.
3. There is a psychological reality to the phonemic system which the linguist derives.

The first and third of these have been quite generally accepted by linguists. The second, however, has been more narrowly received and does not fit the assumptions of tagmemic theory, under which many recent orthographies have been developed.

For the first half of this century, Bloomfieldian linguistics, behaviorist psychology, together with the notion that the reading process was merely transforming visual symbols into speech, favored the continuation of a strong commitment to a one-to-one symbol-to-phoneme design practice.

In recent years, all three of these influences, which formed the basis for the "writing represents speech" position, have undergone almost total reversals and, thus, set the stage for a careful review of the practice of orthography design. In the past 25 years, developments in theoretical linguistics have been revolutionary. Two major developments that have contributed to concerns about orthography are tagmemics and transformational grammar. The three hierarchies of the tagmemic model have brought about a more equal attention to the phonological, grammatical, and lexical components of language. Transformational grammar, on the other hand, has enabled a clearer definition of the relationship between the phonological and grammatical components of language and has also stimulated extensive study in psycholinguistics.

Likewise, during this period, the field of cognitive psychology has come into being with a theoretical orientation quite opposed to the behaviorism that dominated the scene in American psychology from the 1920s to the 1960s. This revolution in psychology has led to explicit study of the ways in which people acquire and process information—matters central to the study of reading. Cognitive processes of perception, memory, attention, problem solving, and the organization of knowledge have turned out to be far more complex than behavioristic theories had proposed.

To complicate cognitive studies further, the way a person approaches a given task is seen to vary. Newell makes this observation:

> … the same human subject can adopt many (radically different) methods for the same basic task, depending on goal, background knowledge, and minor details of payoff structure and task texture (1972) the same human subject can adopt many (radically different) methods for the same basic task, depending on goal, background knowledge, and minor details of payoff structure and task texture (1972:299).

As a result of these developments in both linguistics and psychology, a very different view of the reading process has emerged (Goodman 1967; Levin and Williams 1970; Gibson 1969). The study of reading has shifted from being method-centered to being pupil-centered and research questions are directed more to learning than to teaching. Scholars have come to recognize that reading, itself, is dependent on complex language skills as well as on the knowledge and experience of the reader. The recognition of these complexities has led the reading process to be characterized as the "epitome" of cognitive tasks (Huey 1908; Gibson and Levin 1975).

Current understanding of the reading process leads us to look for a more satisfying view of the relation of speech to writing.

4. Writing expresses language independently of speech

Writing may be viewed as one of several possible expressions of language. This view recognizes the distinction between the form of language and the means whereby that form is expressed. Uldall writing within the framework of Hjelmslev's glossematics, observed that "it is only through the concept of a difference between form and substance that we can explain the possibility of speech and writing existing at the same time as expressions of one and the same language" (Uldall 1944:11).

Vachek argues that "(written utterances) cannot be simply regarded as optical projections of (spoken utterances)" (Vachek 1945:87). They differ not only in material, but more importantly in function.

> The function of the spoken utterance is to respond to the given stimulus (which, as a rule, is urgent) in a dynamic way, that is, quickly, readily, and with equal attention to both the intellectual and the emotional factors of the situation that gave rise to the stimulus. On the other hand, the function of the written utterance is to respond to the given stimulus (which, as a rule, is not

> urgent) in a static way, that is to say, the response should be permanent (that is, preservable), affording full comprehension as well as clear survey of the situation concerned, and stressing the intellectual factors of the situation (1945:87).

Vachek also suggests that, in literate communities, writing functions as "a sign of the first order," that is, as a direct expression of language. The spoken and written functions are distinct to the point where Vachek considers literates as "something like bilinguists because they command two standards of language, the spoken and the written one."

This view of writing makes several claims about the independence of writing. First, writing expresses a style and vocabulary that is distinct from speech at some points. Second, in normal reading, words are recognized before they are pronounced. As was noted earlier, English contains a number of "visual morphemes" (Bolinger 1946), some of which are not encoded phonologically, such as numbers, nonalphabetic symbols (=, @, #, and so forth), and other uniquely encoded forms. Finally, writing systems in use never do fully represent all of the phonemes of the language.

5. Implications for encoding relations

What are the implications of these views for the practice of orthography design? The first position, the "writing represents speech" view, imposes strong restrictions on encoding options. In theory, this means that symbols are assigned in a tight one-to-one relation to phonemes. The linguist is then obligated to count for and to defend each deviation from the theoretical idea. The effect of this position has been to minimize or to overlook the importance of information that is not strictly phonological. More importantly, I feel it has stifled creative development in orthography design by discouraging linguists from taking a more general view of the ways language conveys information.

On the other hand, the view that writing is an independent expression of language encourages the linguist to consider a wider range of encoding options, in that all of the features of language, phonological and grammatical as well as lexical, are candidates for orthographic expression. Potentially, there can be a more general consideration of the needs of the reader and learner as well as a broader perspective toward orthography design.

Gudschinsky's papers of 1972 and 1974 reflect a move in this direction. Although she retained a phonology-based view of orthography design, her later works recognized the broad range of information that orthographies can and do provide.

A more general view toward orthographic encoding may not result in radical differences, in the actual form of orthographies, as compared to those that are primarily phonology centered. In many cases, orthographies prepared under this broader perspective may show only minimal differences from their counterpart designs. They should, however, differ from phonology-centered orthographies in several ways:

1. A lower level of lexical ambiguity
2. A higher degree of consistency of morpheme shape

3. Greater attention to conventional aspects of capitalization, paragraphing, and punctuation as they relate to higher level units (that is, phrase, clause, sentence boundaries, and so forth)

4. A reduction of phonological encoding accompanied by increased grammatical and lexical encoding.

6. Degree of encoding

We turn, now, to consider some psychological consequences of reducing encoding relations. This brings into focus questions that deal with the quantitative aspects of encoding. How much information, carried by the language being written, must be conveyed in order for the orthography to be considered adequate? That is, to what extent can a system be reduced without reducing the potential of readers to learn or to achieve fluency in reading it?

There are three related concepts which bear on these questions. The first two are functional load and redundancy. These have been invoked by some who argue for less than fully-encoded orthographies. The third concept concerns types and levels of ambiguity which result from failing to signal certain contrasts in the system.

7. Functional load and redundancy

[Topics: functional load, redundancy]

In defending less-than-fully-encoded orthographies, linguists are prone to call on the notion of functional load. The notion itself is borrowed from historical linguistics and is defined broadly as the extent to which a contrast functions in keeping utterances apart (Hockett 1955; Greenberg 1959). Hockett describes it in this way:

> Assuming that two phonemes, *x* and *y*, can contrast at all, then the functional load carried by the contrast will be greater if both *x* and *y* have relatively high-text frequencies than if one has a high frequency and the other a low frequency, and greater under those second conditions than if both *x* and *y* have low frequencies. The large number of pairs of English words, differing only in the presence of /p/ or of /b/ at a certain point, obviously implies that potential existence of a larger number of long minimal pairs turning on /p/ and /b/ than on, say, /p/ versus the relatively low-frequency /s/; yet, one will expect a larger number of the latter than of minimal pairs turning on /s/ versus the very low-frequency /z/. Therefore, we can be pretty safe in concluding that the /p/:/b/ contrast carries a higher functional load than the /p/:/s/ contrast, and the latter a higher load than the /s/:/z/ contrast—indeed, the functional load of the last contrast must be vanishingly small.

Various procedures, for quantifying functional load, have been suggested. It is generally agreed that functional load is related to the concept of entropy in information theory (Hockett 1955; Greenberg 1959; Wang 1967; Powlison 1968). Some procedures calculate the bit values of information at points where

phonemes of the pair may be substituted. Hockett defines the functional load as "the ratio of the entropy which would be lost if the contrast were abolished to the entropy of the unchanged system" (1955:217). This means that the sum of the functional loads of all contrasts, within the system, is equal to the total entropy of that system. There are at least two problems with applying this approach. First, the approach regards only phoneme sequences and does not recognize other relationships within the string of symbol sequences, such as grammatical or lexical patterns. Secondly, although these calculations may be useful as rough estimates with which to weigh alternatives, they do not, in themselves, define the limits at which communication is impaired, should one or more contrasts be removed from that system.

Greenberg computes what he refers to as "functional yield for tone in four languages." Phonemic yield is obtained by "dividing the total number of substitutions of any phoneme for any other phoneme by the total number of phonemes in the texts examined" (Greenberg 1959:11). The texts, used in the study, all contained less than 250 phonemes. A weakness of this procedure is the arbitrary way in which the substitutions are judged to be valid. Greenberg accepted substitutions that were grammatically possible, even if semantically improbable, across the span of the given text.

A second calculation, related to phonemic yield, Greenberg labels "compactness." This is a measure similar, mathematically, to the calculation of entropy but differs in that the set of possible substitutions replaces the set of symbols in the entropy calculations. It shares the weakness of Hockett's entropy ratio in that calculations beyond the second order become prohibitively difficult. Furthermore, there is no principle to limit the number of orders to be calculated.

Powlison attempts to make the notion of functional load more practical to the orthographer with five factors for consideration (Powlison 1968:87–90):

A. **With how many other phonemes of the language does the phoneme contrast to keep utterances apart?** For example, in a two-level tone system, high tone contrasts only with low tone, but a voiceless bilabial stop may contrast with 10 or more other consonants. The more phonemes with which it contrasts, the greater the functional load, other things being equal.

B. **By what kind of features does the phoneme differ from the next most similar phoneme with which it contrasts to keep utterances apart?** By *point of articulation*—bilabial, palatal, velar, for example, /b/ versus /d/ versus /g/? By *manner of articulation*—nasality, cavity closure, tenseness, … for example, /n/ versus /t/ versus /c/ …? By *point of articulation*—labialization, palatalization, aspiration, … for example, /kw/ versus /ky/ versus /ky/ …? A difference in *point of articulation* from the next most similar phoneme will indicate a greater functional load than a difference in *manner of articulation,* and a difference in *manner of articulation* will indicate a greater functional load than a difference in *point of coarticulation,* **other things being equal.**

C. **By how many phonetic features does the phoneme differ from the next most similar phoneme with which it contrasts to keep utterances apart?** For example, (p) differs from (m) in nasality, voicing, and aspiration. The more phonetic features in which it differs from the next most similar phoneme, the greater the functional load, **other things being equal.**

D. **On how many levels does the phoneme keep utterances apart?** For example, I want to buy a kit /kIt/. I want to buy a mitt /mIt/. Here, we have two utterances, kept apart in meaning only by the *k-m*

contrast in two different words, both of which belong to a class of nouns. This is on the *lexical* level. On the *grammatical* level, there is the following example: in the Bora language of Peru, the continuative and intensive aspects are distinguished only by tone in the single-syllable verbs having long vowels … the tone may function alone to distinguish meanings on complex sentence level and even above. A phoneme, which functions to keep utterances apart on both lexical and grammatical levels, will bear a heavier functional load than those which do it only on the lexical level, or only on the grammatical level, **other things being equal.**

E. **How many clues, concordances, collocations, or redundancies are there in the context which will anticipate this phoneme, rather than another with which it contrasts?** For example, I am the catcher of the local baseball club. I want to buy a (mitt/kit)/ The more clues, concordances, collocations, and redundancies in the context, the less functional load will be carried by a given phoneme, **other things being equal.**

This definition comes much closer to what the orthographer actually means by functional load, yet the procedures are now far more complex, and the orthographer is apt to be left wondering, just when other things are equal, as well as how he is to know when he is finished.

8. Redundancy

[Topics: redundancy]

There are two types of redundancy important to the level of orthographic encoding. Distributional redundancy, the first, exists when substitutable items are not equiprobable. This is so, in that the knowledge of the differences in the probabilities leads to less uncertainty as to what item will actually occur in a given situation than equal probability would give. Redundancy of this sort is paradigmatic, in that it treats probability of occurrence in slots or positions. For example, in English, the class of consonants that can occur in word-final position is smaller than the class that can occur in word-initial position. The level of distributional redundancy is higher in the word-final position.

Sequential redundancy, the other kind, is syntagmatic, in that it treats probability of occurrence in a sequence. Sequential redundancy exists when a given item conditions the probability of occurrence for that item or items which follow. Consonant-vowel patterns are one source of sequential redundancy (Shannon and Weaver 1949). In English, the likelihood that a vowel will occur following two consonants is very high.

Redundancy of both types exists not only in phonological patterns, but in grammatical and lexical patterns as well.

The level of combined redundancy for the phonologic system of English is approximately 50 percent (Shannon and Weaver 1949; Hockett 1955). This means that, under ideal communication conditions, a substantial portion of the speech signal can be deleted or covered with noise and the message still remain recoverable.

Although total language redundancy is impossible to quantify precisely, the existence of redundancy in language is what allows any reduction of encoding at all in the written form. If limits of encoding adequacy can be determined for a writing system, it is reasonable to assume that they will relate directly to the level of overall redundancy for that language.

9. Ambiguity

[Topics: ambiguity]

An orthography with reduced encoding, either through omission of a symbol in the system or through neutralization of a contrast in the system, increases the ambiguity or uncertainty for the reader in accordance with the nature and extent of alterations. I use the term "ambiguity" in a broad sense to include a variety of types, such as graphic, phonological, lexical, grammatical, semantic, and textual. A reduction of a contrast in an orthography may result in one or more types of ambiguity wherever that contrast occurs within text. Furthermore, the resultant ambiguity may exist at one or more structural levels of the text, such as the character, word, phrase, sentence, and paragraph.

The remainder of this section is an attempt to deal with the notion of ambiguity, both quantitatively and qualitatively, in a way that will allow cross-language generalization.

Qualitatively, uncertainty can be defined in two ways: range of ambiguity and depth of ambiguity. The range of ambiguity deals with the syntagmatic aspects of uncertainty or sequential redundancy and refers to the extent of the context necessary to resolve a given ambiguity. If we view ambiguity as a point of potential substitution, we can express range in terms of types.

A substitution may be:

1. **Graphically valid.** A substitute can be graphically possible, in that it obeys the rules of orthographic structure, yet not necessarily be possible lexically, in that the result need not be a real word.

2. **Phonologically valid.** A substitute can be phonologically possible, in that it can be pronounced, yet not necessarily be possible lexically, in that it need not be a real word.

3. **Lexically valid.** A substitute can be lexically possible, in that it is a word, yet not necessarily be possible grammatically, in that the word need not be of the right class for the substitution point.

4. **Grammatically valid.** A substitute can be grammatically possible, in that it is a word of the same function class, yet not necessarily be possible semantically, in that it need not make sense.

5. **Semantically valid.** A substitute can be semantically possible, in that it makes sense, yet not necessarily be possible textually, in that it does not fit the context.

6. **Textually valid.** A substitute can be textually possible, in that it fits the context, yet not be the form chosen by the author.

Depth of ambiguity, on the other hand, deals with the paradigmatic aspects of uncertainty or distributional redundancy. It refers to the number of alternative possibilities at each point of ambiguity. Theoretically, this can be defined for each of the types of ambiguity just described. In general, the depth of ambiguity is expected to be less in the higher levels because the set of constraints is larger.

Quantitatively, uncertainty can be defined as density of ambiguity. It is measured as the rate of ambiguities and described as the ratio of points of ambiguity to the number of characters or to some other metric of text quantity. The density of ambiguity induced by the neutralization of a contrast could be treated as an index of the functional load of that contrast. As the practice of orthography design turns toward a broader approach to the visual encoding of language, the consequences of specific orthographic decisions can be widespread and not easily detected or evaluated. Further research in the area of encoding relations and degree of encoding is needed, both to make these consequences more apparent and to establish a psycholinguistic definition for encoding adequacy.

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