Phonetic Activity in Reading: An Experiment with Kanji*

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The Nature of Silent Reading

People have read aloud, and have been read to, for a very long time, but silent reading of substantial amounts of text has been until recently a fairly rare human accomplishment. In his Confessions (397 A.D.), Book VI, Augustine records his amazement at discovering his teacher, Ambrose, reading to himself: "When he was reading, his eye glided over the pages, and his heart searched out the sense, but his voice and tongue were at rest."

But silent reading is not necessarily silent. Indeed, for anyone who wants to understand this process, a basic problem is the nature, function, and extent of the concomitant phonetic activity. Such activity may conceivably be audible; or inaudible, but characterized by observable articulatory movements; or neuromotoric, without physical movement; or purely central. Some modern "silent" readers of English still move their lips and tongue or subvocalize, though such behavior is socially unacceptable in middle-class culture and is considered "immature" by teachers of reading. Many other readers who are deemed both mature and socially acceptable report that though they read silently, they are nevertheless aware as they read of a flow of phonetic imagery through the mind--a flow that has frequently been called "inner speech" (Huey, 1908; Goto, 1968). These readers, at least, will notice that a sentence such as "The rain in Spain falls mainly in the plain," has a phonetically bizarre pattern, although they have neither spoken the sentence nor heard it. With electromyographic techniques, attempts have been made with partial success to demonstrate a connection between inner speech and the neuromotor activity in the muscles that control the articulators (Sokolov, 1968).

Further evidence of phonetic activity during reading comes from experiments in visual information processing. One general finding is that when subjects are asked to perform a task requiring recall from short-term storage of letters or words read a few seconds before, the kinds of errors the subjects make suggest

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that this storage is phonetically organized (Conrad, 1972; Sperling, 1963). This kind of phonetic activity might well be purely central.

At any rate, some kind of phonetic activity often accompanies silent reading. But the function of this activity is not clear. Of course, the beginning reader has to acquire and exploit at least a passive knowledge of the spelling-to-sound rules of English in order to recognize in print a word that he has hitherto known only in its spoken form, and a mature reader uses these rules to assign a pronunciation to a printed word that he has not seen before. But even though the alphabet is in itself quasi-phonetic, English orthography, as Chomsky and Halle have insisted, is a better fit to the phonological than to the phonetic level of the language (Chomsky and Halle, 1968; Chomsky, 1970). That is, the spelling-to-sound correspondences exploit the linguistic rules that determine how the phonological representation of a morpheme is to be phonetically realized. Thus the regular plural morpheme /s/ is written s even though this morpheme is phonetically [əz], [z], or [s] according to phonological context, and /sign/ is sign in sign, resign, and signify, though pronounced differently in each of these three words. It might seem, therefore, that for a mature reader who is reading familiar material, phonetic activity is not only unnecessary but must pointlessly complicate the task. Since he is given in the printed text an essentially phonological representation and does not want to read it aloud, why can he not simply omit the reconstruction of the phonetic form of what he reads and deal only with syntactic and semantic reconstructions? Some people think that a genuinely skilled reader does in fact do just this, and there are some so-called "visual" readers who claim to go even further (Bloomfield, 1942; Bever and Bower, 1966; Bower, 1970). Like Ambrose, they glide over the pages, they report no inner speech, and they say that they "go directly to meaning" without any intermediate processing. It is difficult to know what to make of such claims, and we will return to them later. But at the very least, they seem to cast further doubt on the utility of phonetic activity during silent reading. Perhaps, as has often been suggested, phonetic activity in the mature reader is just an unfortunate vestige of early training to read aloud, and the less of it, the better.

But if phonetic activity is necessary to silent reading, we might still expect this to be true only in the case of alphabetic and syllabary orthographies, since these are the two classes of writing systems that overtly exploit the grammatical rules that generate phonetic representations. To be sure, the level of phonological abstractness varies substantially from one writing system to another. Finnish, Spanish, and Russian orthographies correspond in a fairly straightforward way with their respective phonetic systems, while the spelling-to-sound rules for English and French orthographies are quite complex. But regardless of the degree of abstractness, the rules of these writing systems parallel the phonological rules closely. Logographic writing, however, in which the symbols represent morphemes or morpheme compounds, might perhaps be processed quite differently. The reader of Chinese characters or Egyptian hieroglyphs might quite reasonably be expected to go directly to a morphemic representation, at least, if not to "meaning."

Yet a commonplace observation suggests that in at least one case, phonetic activity during the reading of symbols that have no overt phonetic structure at all, may be not only possible but perhaps, after all, necessary. Numerals have no such structure, yet almost all of us subvocalize vigorously when doing arithmetical computation on paper. Of course, subvocalization may be merely an indication of the difficulty of the task, and hence no more relevant than subvocalization while tying a necktie or doing a jigsaw puzzle: we may be subvocalizing not the numbers themselves, but about the numbers.

But a result obtained by Klapp (1971) suggests more conclusively that the reading of numerals requires phonetic processing: the time taken to press a key to indicate that a pair of numbers were the same was measurably shorter for two-syllable numbers (e.g., 15 and 15) than for three-syllable numbers (e.g., 17 and 17). Still, it could be argued that the set of number words is too small to be interesting, or that, in Martin's (1972) phrase, numbers are "technological inventions thrust upon natural languages" and should not be the basis of general conclusions about the processing of linguistic symbols.

To sum up our difficulties, then, there is impressive evidence that some readers read silently with accompanying phonetic activity. Yet this activity is not obviously functional nor can we be sure that it is confined to writing systems that exploit phonological rules.

The Kanji Writing System

Let us turn now to consider more closely a writing system that, being logographic, would seem unlikely to necessitate phonetic activity: Japanese kanji.[1] The kanji characters were borrowed from the Chinese during several different epochs. They are logographic: a character represents a lexical morpheme without overt reference to its phonological or phonetic form. The morphemic value of a character is its "reading." Some characters have a Sino-Japanese reading derived from the Chinese reading of the character at the time of borrowing; some have a native Japanese reading; some have both kinds of reading; and some, having been borrowed more than once, have two or more readings of either or both kinds. Most of the characters consist of two elements: the "radical," which serves as a rough semantic classifier, and the "phonetic," so called (though misleadingly for our purposes) because it originally stood for a word similar in sound to the word represented by the character. Foreign words are spelled out with characters from an auxiliary writing system, the kata-kana, and a second kana system, the hiragana, is used in conjunction with the kanji for grammatical morphemes. In both kana systems there is a character for each vowel or consonant-vowel combination in Japanese; the kana scripts are quasi-phonetic. Moreover, the kana can represent adequately the vowel or consonant-vowel moras of which Japanese words are, phonologically speaking, composed.

Many Japanese with whom the authors are acquainted, and some Japanese linguists (e.g., Suzuki) claim to be visual readers of kanji. They say that they extract the meaning directly from the symbols without any phonological or phonetic activity. In this particular case, this claim is the more appealing for three reasons. First, even though the kanji were borrowed a long time ago, the original pictographic or ideographic reading of some of the most common characters still has some mnemonic value. For example, 山 , originally , means "mountain."

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[1]The brief account of Japanese writing given here is based on Palmer (1931), Suzuki (1962), and Martin (1972).

Second, spoken Japanese is inordinately homophonous, in part, as Martin (1972) says, because the Japanese ignored the contrasting tones of the Chinese morphemes they borrowed. There are extraordinarily many pairs of homophonous morphemes, and there are some homophonous sets with as many as 18 members. Moreover, there are numerous pairs whose members, unlike most homophonous pairs in English, are grammatically and semantically commutable, and must frequently give rise to real ambiguity. For example, the words for "national anthem" and "national flower" are homophones; so are the words for "integer" and "positive number." But sets of homophones have, in general, a different kanji character for each morpheme, and naive literate speakers seem to feel that the bond between a morpheme and its kanji is somehow more basic than the bond between the morpheme and its phonological form, the latter, according to Suzuki (1962) being "relegated to the background of our consciousness."

A third reason for attaching some weight to the claim that kanji are not read phonetically is provided by a study of Sasanuma and Fujimura (1971). They have reported that Japanese aphasics with apraxia of speech perform less well certain tasks requiring visual recognition and writing of kana than do aphasics without apraxia, while the two groups perform comparable tasks with kanji about equally well. This would seem to be consistent with the notion that some kind of phonetic activity is needed to read the kana but not to read the kanji.

An Experiment in the Recall of Kanji

In experiments with English-speaking subjects, it is generally found that confusions in short-term retention of alphabetic material are more often due to phonetic similarity between presented and recalled items than to visual or semantic similarity. It therefore is assumed that in retaining verbal material the hypothesized short-term storage system works primarily with a phonetic representation (Adams, 1967; Neisser, 1967). In the view of some students (e.g., Conrad, 1972; Liberman, Mattingly, and Turvey, 1972) this characteristic of short-term storage is of great importance to the reading process. However, in light of what we have just been saying about the unphonetic nature of the kanji and the attitude of native Japanese readers toward their language, we might expect to find that silent reading of kanji is not accompanied by phonetic activity of any kind, including in particular phonetic short-term memory. Such activity would seem to be not just superfluous, but a clear step backwards into homophony.

To test this hypothesis we made use of the probe short-term memory paradigm (Waugh and Norman, 1965). The procedure consists of presenting the subject a series of verbal items. On completion of the list one item from the list is presented as a "probe" and the subject's task is to identify the item that appeared immediately before the probe in the list: the "probed-for" item. The advantage of this procedure is that it allows for the separation of short-term storage effects from long-term storage effects. According to current memory theory, both the relatively transient representations in short-term storage and the relatively permanent representations in long-term storage support the retention of material over brief periods of time by short-term memory (Waugh and Norman, 1965; Atkinson and Shiffrin, 1968).

A recent experiment by Kintsch and Buschke (1969) is especially relevant to our present inquiry. These authors found that in a Waugh-Norman probe paradigm, a subject is less likely to retrieve the probed-for item from short-term storage if the items on the test list are homophones of one another. However, the presence of homophones has no effect on retrieval from long-term storage. By contrast, if the items on the list are semantically similar to one another, retrieval from short-term storage is not affected, but retrieval from long-term storage is. We used this same tactic in an attempt to determine whether similar relations exist between phonetic and semantic similarity, and retrieval from short-term and long-term storage, when the material to be remembered is kanji characters.

Materials and design. Seven sets of 16 words were compiled. All the words used were concrete nouns of two moras and were written with one kanji containing 8-14 strokes. The nouns usually had only a single, Sino-Japanese reading but occasionally two readings were possible. Three of the seven sets were used for construction of practice lists to acquaint the subject with the procedure and to insure that in the actual experiment, practice effects would be relatively small. The other four sets were used to construct the experimental lists; they are given in Figures 1-4. One set (PS) consisted of eight pairs of words that were not only phonetically similar but in fact homophonous. In this set, all words ended in /ō/. A second set (SS) consisted of pairs of semantically similar words. A third set (OS) consisted of pairs of orthographically similar words: the radical elements in both members of a pair were the same, while the phonetic elements in both were different. A fourth set (NS) consisted of words that had no systematic similarity. Native informants were consulted informally about the compilation of all four sets. The SS set was particularly difficult to compile. The informants seemed to feel that the meaning of a word is so intimately related to its kanji that two words having different kanji can never be really synonymous, but only near in meaning to each other.

From each of these four 16-word sets 20 randomly permuted lists were constructed, subject to the following restrictions:

(a) One member of a pair of similar words could not immediately follow the other in a list, so that the probed and the probed-for words in a list were never similar.

(b) Across the 20 lists, each word served at least once, but not more than twice, as a probe and as a probed-for word.

(c) The probed-for word occurred twice each in list positions 3, 5, and 7, once each in positions 4 and 6, and four times each in positions 11, 13, and 15.

(d) In half the lists the probed-for word was 6 or 7 positions away from and in the other half of the lists it was 2 or 3 positions away from the word similar to it.

(e) In half the lists the probed-for word occurred earlier and in half occurred later the word similar to it.

Subjects. All subjects were members of a class in English for foreign students at the University of Hawaii. Ten were Japanese. Two other subjects, a Chinese and a Korean, were included because they could be expected to be familiar with the writing system but not with the Japanese language. [The Koreans have their own alphabet, but Chinese characters are traditionally used to write the numerous Chinese loanwords (Martin, 1972).]

PS List

	Reading	Kanji	Meaning
1	JŌ	城	castle
		嬢	girl
2	HŌ	砲	cannon
		報	report
3	BŌ	棒	stick
		帽	hat
4	CHŌ	腸	intestines
		蝶	butterfly
5	TŌ	燈	light
		陶	pottery
6	BYŌ	秒	second (time)
		病	illness
7	RYŌ	領	territory
		寮	dormitory
8	SŌ	僧	priest
		荘	inn

Figure I

SS List

Meaning	Kanji	Reading
1 edge	縁	En, fuchi
	端	Tan, hashi
2 container	瓶	BIN
	壺	tsubo
3 room	室	SHITSU
	房	BŌ
4 grave	墓	haka
	塚	tsuka
5 district	郡	GUN
	県	KEN
6 evening	夜	yoru
	晩	BAN
7 bowl	椀	WAN
	鉢	hachi
8 mausoleum	陵	RYŌ
	廟	BYŌ

Figure 2

OS List

	Radical	Kanji	Reading	Meaning
1	金	錠	JŌ	lock
		銃	JŪ	gun
2	女	姪	mei	niece
		婿	SEI	son-in-law
3	土	壕	GŌ	mound
		壇	DAN	platform
4	石	磯	iso	beach
		碑	HI	monument
5	月	脳	NŌ	brain
		膳	ZEN	tray
6	糸	紋	MON	crest
		線	SEN	line
7	木	棺	KAN	coffin
		校	KŌ	school
8	阝	院	IN	temple
		陣	JIN	battle line

Figure 3

NS List

Kanji	Sino-Japanese Reading	Meaning
1 週	SHŪ	week
2 湾	WAN	bay
3 輪	RIN (wa)	wheel
4 像	ZŌ	statue
5 剣	KEN	sword
6 税	ZEI	tax
7 頬	KYŌ	cheek
8 綿	MEN	cotton
9 街	GAI	street (town)
10 談	DAN	story (talk)
11 隊	TAI	troop
12 塩	EN (shio)	salt
13 銀	GIN	silver
14 服	FUKU	cloth
15 斑	HAN	spot
16 穀	KOKU	kernel

Capital letters indicate Sino-Japanese readings; small letters, Japanese readings.

Figure 4

Procedure. Following a practice series, the 80 lists were presented on film strips to each subject in four blocks of 20, corresponding to the four similarity conditions. The words were presented at the rate of one per second, and the subjects read each word silently. One second after presentation of the last word on a list, the probe word (underlined) for that list was presented. The subjects then had to write down on a response sheet the kanji that had appeared immediately before the probe in the list. The position of the probed-for word was never the same on successive lists, nor did the same words or members of a similar pair appear as probed or probed-for words on successive lists. The four conditions were partially counterbalanced across the twelve subjects in a Latin-square design such that each condition appeared three times.

Results. Table 1 gives the recall probabilities averaged across the ten Japanese subjects for the kanji words of each condition as a function of serial position of the probed-for word. Inspection of Table 1 suggests that later items were recalled better than earlier items and that recall of PS words was poorer than recall of NS words, while recall of SS and OS words was not significantly poorer.

TABLE 1: Recall probability as a function of serial position for the Japanese subjects.

Condition	Average of Positions 3, 4, 5, 6, 7	Positions 11	13	15
NS	.13	.08	.22	.50
PS	.07	.00	.12	.35
SS	.10	.10	.18	.50
OS	.08	.10	.27	.52

We have already noted that performance in experiments where subjects are required to retain material over brief periods does not rely on short-term storage probability alone; rather, it is jointly determined by short-term and long-term storage probabilities (Waugh and Norman, 1965). Taking the view that the two storage systems are stochastically independent, Waugh and Norman proposed that in the probe short-term memory paradigm the probability of recalling an item is position $\underline{i}$, $\underline{P}(\underline{R}_i)$ is:

$$\underline{P}(\underline{R}_i) = \underline{P}(\underline{STS}_i) + \underline{P}(\underline{LTS}) - \underline{P}(\underline{STS}_i)\underline{P}(\underline{LTS})$$

where $\underline{P}(\underline{STS}_i)$ is the probability that item $\underline{i}$ is retained in short-term storage (STS) and $\underline{P}(\underline{LTS})$ is the probability that it is retained in long-term storage (LTS). The assumption is made that $\underline{P}(\underline{LTS})$ is independent of the position of an item in the list. $\underline{P}(\underline{STS}_i)$ is maximal for the most recent item, and decreases monotonically as a function of the distance from the end of the list, reaching zero after approximately 7-9 intervening items. If we regard the mean recall probability of items in positions 3, 4, 5, 6, and 7 as an estimate of $\underline{P}(\underline{LTS})$ then the equation above can be used to compute the STS component of the present data unconfounded by the LTS component.

Estimates of STS for positions 15, 13, and 11 were calculated in this fashion for each of the four conditions and are given in Figure 5 which also includes the corresponding LTS estimates. In Figure 5 we can see that retrieval from STS was significantly affected by phonetic similarity between the kanji but not by either semantic or orthographic similarity. This observation was borne out by a Wilcoxon matched-pairs test which showed a significant difference between PS and NS ($\underline{P}<.05$) but no significant difference between SS and NS, or OS and NS. This is consistent with the finding of Kintsch and Buschke (1969) for short-term recall of English. A similar analysis conducted on the LTS estimates revealed no significant differences: perhaps because of the difficulties mentioned earlier in compiling semantically similar sets of kanji, we did not find for Japanese an effect of semantic similarity on long-term recall paralleling Kintsch and Buschke's for English.

The STS and LTS estimates averaged across the two non-Japanese subjects are given in Table 2. There are not enough subjects to provide results that

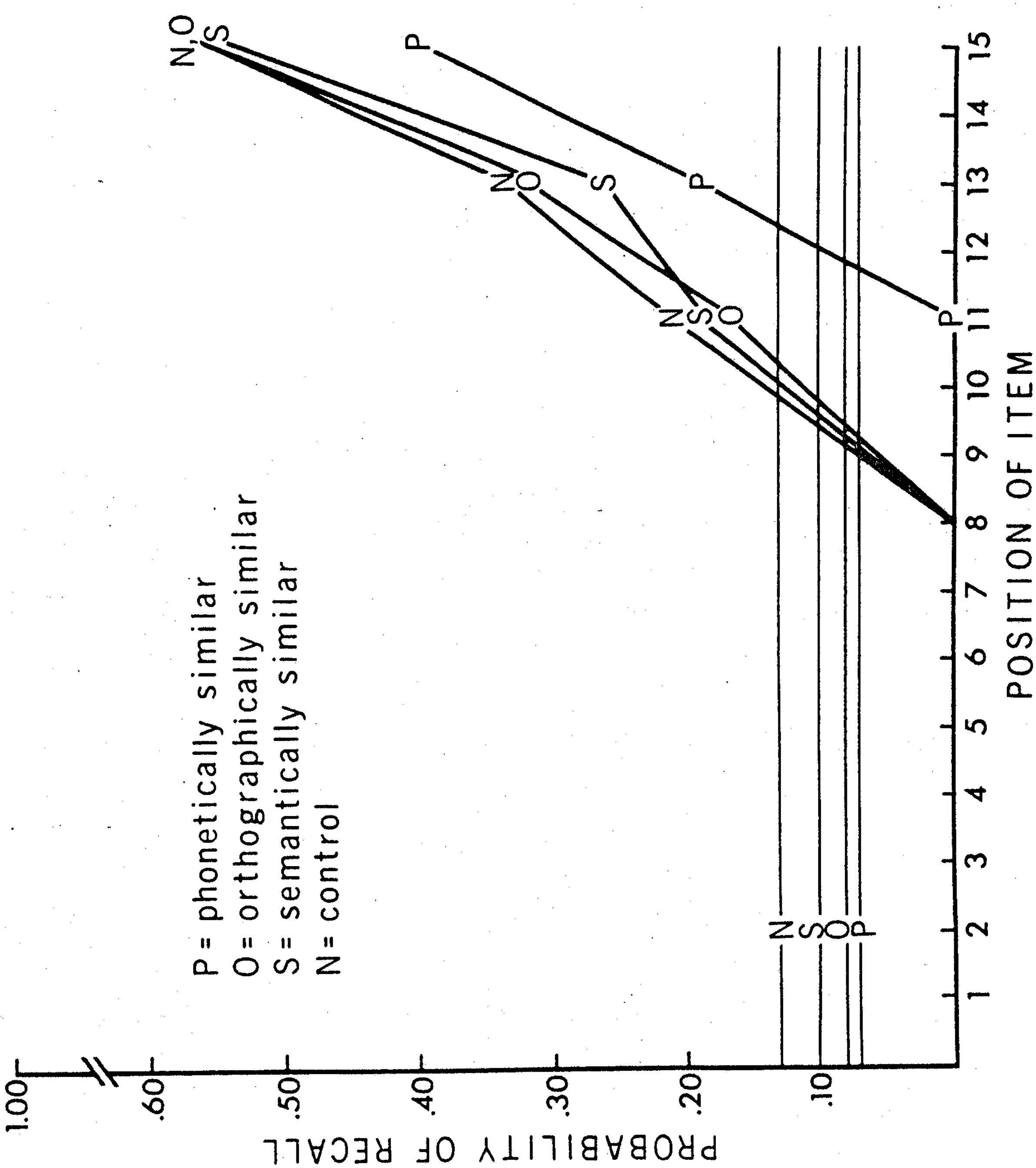
TABLE 2: Short-term and long-term storage estimates averaged for the Chinese and Korean subjects.

Condition	LTS Estimate	STS Estimates for Positions: 11	13	15
NS	.20	.03	.66	.84
PS	.15	.08	.39	1.00
SS	.15	.09	.28	.60
OS	.00	.30	.50	1.00

can compare in general with those from the Japanese, and in addition, a sequence effect may well be operating in the non-Japanese data. In any event, we do not know whether the relatively low SS score is significant, or why the LTS estimate for OS should be zero. Nor can we comment on the apparently higher level of STS performance achieved overall by the non-Japanese subjects. But the lack of any apparent PS effect for these two subjects offers some small assurance that the PS effect achieved with the Japanese subjects is not owing to some nonlinguistic artifact.

Discussion

In considering the significance of this experiment, we should keep in mind that its design was biased in several respects against the result that was obtained. The stimuli had no overt, systematic phonetic structure; the subjects, like most Japanese, did not believe that they used phonetic information in their ordinary reading of kanji text; linguistic considerations, as we have pointed out earlier, suggest that from a phonetic viewpoint Japanese is a less



P = phonetically similar
O = orthographically similar
S = semantically similar
N = control
PROBABILITY OF RECALL
1.00
.60
.50
.40
.30
.20
.10
POSITION OF ITEM
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
N
S
O
P
N,O
S

Figure 5

than efficient means of communication; and the particular experimental task was such that a strategy that took account of the phonetic value of the characters would be likely to be a serious handicap with the PS set. Yet the significant difference between the PS and NS scores suggests that, despite these considerations, the subjects did resort to a phonetic strategy, and presumably they had a very good reason for doing so. We must try to establish what this reason could have been and what its implications are for an understanding of phonetic short-term storage, of the linguistic process, and of reading.

Phonetic short-term storage. The first observation that we can make concerns the conditions required to produce phonetic short-term storage effects in the visual processing of alphabetic material. There seem to be two possible views. The first is that the letters of the alphabet--quite aside from the lexical items they are used to represent--correspond with some degree of consistency to the phonetic values of a broad transcription, and since these correspondences are very familiar to the subjects, it is this primarily phonetic aspect of the letters that produces phonetic short-term storage effects, rather than any more abstract phonological, morphological, or syntactic factors. This view implies that phonetic activity is in principle readily separable from linguistic activity, and is all the more appealing because linguists, for their part, have traditionally insisted on the exclusion of phonetics from linguistics. It would follow that symbols that are not phonetic would evoke either some kind of nonphonetic short-term storage activity of their own, or no short-term storage activity at all. The second possibility is that, on the contrary, it is not the specifically phonetic but the more globally linguistic significance of alphabetic material that is important; phonetic short-term storage is only one component of a more general system for processing linguistic information, evoked by the task of reading the alphabetic stimuli. In this view, the nature of the short-term storage activity would depend on the system as well as the symbols, and phonetic activity evoked by nonphonetic symbols would not be surprising.

There is, of course, no way to distinguish these two possibilities clearly with alphabetic material. And it might be argued that the present experiment with kanji does not permit a perfectly clear distinction either, for the kanji do have phonetic values, in the sense that each symbol represents a lexical morpheme to which a phonetic value, i.e., its pronunciation, is assigned. Despite what has been said about the differences between logographic and alphabetic scripts, the reader of kanji controls a set of fixed, familiar correspondences between written symbols and spoken sounds just as the reader of the alphabet does. The difference is merely a matter of degree, the ensemble of units used for the short-term storage encoding being greater in the case of the kanji, and the units corresponding to longer phonetic events. Furthermore, it is irrelevant that the reader of kanji learns these symbols through the mediation of morphemes, since a similar observation might be made about many readers of the alphabet. Thus our result might be dismissed, though in a way that not only trivializes the experiment but also does violence to the intuitions of the native speaker of Japanese about his language and his writing system.

Fortunately, there is evidence of two sorts against the argument that there is no difference in kind between logographic and phonetic writing. First, there is Sasanuma and Fujimura's (1971) observation that the logographic kanji and the quasi-phonetic kana are differentially affected by brain damage. Whatever it may mean, this observation is not what we should expect if both writing systems were of essentially the same kind. Second, there is Wickelgren's (1966) well-known demonstration of phonetic-feature confusions in the short-term retention of alphabetic text. Wickelgren's result suggests that the actual units of coding in short-term storage are to be clearly distinguished from the units symbolized by the characters of the writing system, and that the short-term storage coding is a feature-by-feature representation and thus highly analytic, more so than any traditional writing system.

But if so, then there can be little question of coding the phonetic values of the kanji as monolithic units, and we can continue to regard kanji script (as linguists and native speakers have traditionally regarded it) as a morphologically based writing system. Since our experiment shows that the kanji nonetheless elicit phonetic short-term storage effects, we are compelled to consider seriously the second of the two explanations of such activity suggested above: the phonetic activity depends upon the essentially linguistic character of the experimental task. If this explanation is the correct one, it should be possible to demonstrate for any writing system in ordinary use the range of phonetic effects that have been found for alphabetic writing.

The experiments of Reicher (1969) and Wheeler (1970) support further and in a sense complement this view. These investigators found that under identical masking conditions a letter could be more accurately recognized if it was part of a four-letter word than if it was part of a four-letter anagram of this word. Apparently a subject knows that the sequence is meaningful before the process of identifying the letter shape is complete (cf. Turvey, in press). If the visual recognition of quasi-phonetic symbols invokes at the same time not only phonetic but also other linguistic processes, it is not surprising that the recall of symbols that are linguistic, but not overtly phonetic, should invoke phonetic as well as linguistic activity.

Linguistic process. Let us now consider what role phonetic short-term storage might play in the linguistic process. Following Chomsky (1965); Neisser (1967); and Liberman, Mattingly, and Turvey (1972), we regard what we shall call "primary linguistic activity" as a process of constructing a semantic representation and a phonetic representation. The phonetic representation is in a form appropriate for transmission; it is a specification for a certain pattern of articulatory activity being executed by a speaker and tracked by a listener. The semantic representation is in a form appropriate for storage; its relationship to long-term activity is parallel to (though as yet much less clearly understood than) the relationship of the phonetic representation to speech.

At present, we do not understand how the speaker-hearer constructs these representations. There are serious difficulties with the various simple models that have been proposed. We know a good deal about the form of the grammar that relates the two terminal representations of a given sentence, but we also know that we cannot map grammar into psychological process in any very straightforward way. We can tentatively infer from the grammar, however, that the construction of the two terminal representations involves several intermediate stages of recoding.

Phonetic short-term storage, as described by investigators of information processing, is clearly quite consistent with this general conception of primary linguistic activity. A basic fact that has emerged from information processing research is that the transformation of information is not instantaneous. It takes a significant (and with current techniques, measurable) amount of time, for example, to register a visual "icon" and still more time to identify it as, say, a particular letter (Turvey, 1973). Therefore, we should expect that for primary linguistic activity in general, an appreciable period would also be required. But if so, a buffer or work-space of some kind is needed in which a representation of a sentence can be stored and updated during the course of linguistic processing. Phonetic short-term storage provides just what is called for. It is thus well motivated on psycholinguistic grounds, quite independently of its value in interpreting the results of information-processing experiments.

This view of the function of short-term storage bears on a question about primary linguistic activity that is very pertinent to reading. Since it has been suggested that there are several stages of recoding during this activity, can part of the process be short-circuited? Is it possible, for example, by presenting the processor with information in a form corresponding to some intermediate stage of recoding, to dispense with the phonetic buffer, and to use a buffer corresponding to this intermediate stage of recoding instead?

It is not at all unlikely that there should be a buffer storage associated with one or more of the intermediate stages of recoding. The prospect of a further proliferation of buffers should not dismay us; as George Miller has remarked (in Kavanagh and Mattingly, 1972:289), one would expect the nervous system to contain a good many buffers, just as the country contains a good many mailboxes. The question is open and obviously requires much further investigation. The outcome of the present experiment, however, gives no encouragement for this notion. The kanji correspond to a morphological or surface-structure representation, and so it might seem that part of the recoding has already been done for the reader of kanji. Yet phonetic activity is apparently necessary nonetheless. Our result is consistent with a very austere model of the linguistic processor in which there is no alternative buffer storage but only the phonetic buffer. Morphological information may require phonetic storage simply because no intermediate, morphological storage is available.

Yet we should be wary of concluding that there is absolutely no alternative to phonetic processing. As Conrad (1972) has shown, children who are congenitally and profoundly deaf develop nonphonetic strategies, no doubt very inefficient ones, for recall of written material, and they do learn to read, though in general poorly.

Reading. We turn now to the implications of our result for the nature of the reading process. We must, of course, proceed quite cautiously in extrapolating from a short-term memory experiment to any generalization about reading. The experiment, though simple in conception, required the subject to perform an apparently new and difficult task, practiced over just a few minutes. Reading ordinary connected text is a much more complex, yet far more familiar task, practiced over many years. But at least we can say that the outcome of the experiment is a further indication of a discrepancy already remarked upon. There is evidence of phonetic processing in the case of the Japanese reader just as there is in the case of an English reader. Those readers who say that they read without phonetic processing may well be reporting their subjective experience accurately, but they are probably processing phonetically, though quite unaware of doing so. Since we have just argued that this "unnecessary" processing is an essential part of primary linguistic activity, and since we might expect that reading, like performing in a verbal short-term memory experiment, requires primary linguistic activity, this conclusion is not really surprising to us. But it seems to lead to a paradox. If phonetic short-term storage is so basic to primary linguistic activity, even when one is dealing with linguistic information in visual form, why are traditional writing systems not uniformly phonetic?

This is a knotty problem, and we can only suggest here the direction in which a solution should be sought. As Vygotsky (1934), Klima (1972), and Mattingly (1972) have suggested, it is possible to distinguish between primary linguistic activity itself and the speaker-hearer's awareness of this activity. If language were deliberately and consciously learned behavior, there would be little point to this distinction. But if we adopt the view of the generative grammarians that language is a very basic, highly elaborated cognitive process, acquired maturationally, our degree of linguistic awareness acquires a new significance. We should not necessarily expect to be any more aware of intermediate stages of linguistic process than we are of intermediate stages of other maturationally acquired behavior, such as walking or seeing. Yet we do seem to have a substantial, though far less than total linguistic awareness, and it is this awareness that, together with primary linguistic activity, forms the basis of various verbal skills that are forms of secondary linguistic activity. It is through the disciplined cultivation of linguistic awareness that speaker-hearers learn to speak a "secret" language like Pig Latin, or to compose verse that scans (Halle, 1970) or to transmit from generation to generation the traditional prose and poetry of a preliterate community. Such awareness, it has been suggested, is likewise the basis of reading and writing--literacy, too, is a secondary linguistic activity. We shall not attempt here to characterize the specific relationship between the secondary and the primary activities--indeed, if we could do so adequately, we would have arrived at an understanding of reading--but we may say that the skill of the reader consists in being able to control his primary linguistic activity in accordance with the written text, so that his awareness of this activity matches the symbols he sees.

Traditionally, of course, educators and even linguists have talked as if reading were in essence a form of speech perception in the visual modality. But in light of what is now known about the very peculiar nature of speech perception, this view seems to entail numerous contradictions, as Liberman (in Kavanagh, 1968) has pointed out.

If our view of reading as secondary linguistic activity is correct, we should expect that linguistic awareness, and not simply the requirements of primary linguistic activity, would determine the form of writing systems. Now the speaker-hearer's degree of linguistic awareness varies considerably over the range of primary linguistic activity; thus he is much more distinctly aware of the morphology of his language than he is of its phonology, and more aware of either of these than of its deep structure or its phonetics. This variation in linguistic awareness is clearly reflected in the history of writing systems (Gelb, 1963; Diringer, 1968). No culture has ever developed a writing system based on distinctive features or phrase-structure tree diagrams: such representations are useful only for linguistic description. At the other extreme, logographic scripts, which are morphologically based, are very ancient and have been invented independently many times. Sometimes those scripts have developed into syllabaries, which require a relatively modest phonological awareness. The alphabet was invented only once, not very long ago. As we have seen, alphabetic writing systems tend to be more nearly phonological than phonetic; rigorously phonetic writing systems have indeed been proposed from time to time, but have never found general acceptance (Wilkins, 1668; Bell, 1867).

The alphabet, then, seems to be the least obvious of the traditional types of writing system. It became popular, however, because its practical advantages--the small size of the symbol inventory and the ease with which it could be adapted to new languages--in general more than compensated for its greater demand upon linguistic awareness. But this does not mean that alphabetic writing is the answer for every language. It is conceivable that the structure of a language, as it presents itself to the linguistic awareness of a native speaker, might be such as to make any quasi-phonetic writing system objectionable, despite the practical advantages. This would seem to be the case with Japanese. As we have already seen, the lexicon is filled with homophones. While this homophony probably does not interfere seriously with primary linguistic processing, it is quite conceivable that a writing system that failed to distinguish members of homophone sets would be highly distressing to the linguistic awareness of Japanese speaker-hearers. They are comfortable with a writing system that is morphologically rather than phonetically based, and understandably reluctant to adopt an alphabetic system that, because of the phonetic characteristics of the lexicon, would represent their language in the most ambiguous possible fashion. The well-meant attempts of reformers to replace the kanji with a Roman alphabet or with the syllabary kana (which do not resolve homophones either) have foundered on precisely this issue (Palmer, 1931).

A further implication for reading concerns the various kinds of phonetic activity discussed in our first section. The distinction we have drawn between primary linguistic activity, on one hand, and secondary linguistic activity dependent on linguistic awareness, on the other, leads us to conjecture that while phonetic short-term storage is a part of primary linguistic activity, the same is not necessarily true of inner speech or subvocalization, the presence or absence of which may vary with the reader, the degree of stress he is under, the writing system, and the content of the material being read. Rather, these latter phenomena seem to be associated with a certain kind of linguistic awareness.

If so, it may be possible to reconcile with our own result the finding of Sasanuma and Fujimura (1971), mentioned earlier, that aphasics with apraxia of speech, but not other aphasics, have special difficulties with kana, but not kanji. The interpretation of their finding suggested by these investigators runs counter to our own speculations: they argue that the kana spelling cannot be identified as a familiar representation of the word, but has to be interpreted as a phonetic code, which in turn can be related to the phonological representation of the lexical entry. A kanji transcription, on the other hand, can be directly identified with a word, bypassing the phonological interpretation, since each word (lexical entry) is independently associated with a kanji pattern as well as a phonological pattern. Thus the apraxic subjects are thought to have difficulty with the kana because they cannot bypass their damaged phonetics and phonology, as they can with the kanji. But there is a problem with this interpretation. If the group of aphasics that have relatively greater difficulty with kana suffer from a phonological impairment, we would surely expect them also to have relatively greater difficulty in speech perception. But the two groups differ only in speech production. Thus there is perhaps less reason to hypothesize a phonological impairment that is bypassed when reading kanji.

We suggest, very tentatively, an alternative explanation. Suppose that these subjects are apt to subvocalize (or engage in inner speech) when they read kana, but not when they read kanji. This would not only agree with the informal reports of normal Japanese readers, but would be consistent with the relationship between subvocalization and linguistic awareness that has been suggested above. The apraxic subjects could be expected to make the same kinds of performance errors in their subvocalizations as in their ordinary speech, and it would not be surprising if the resulting noisy feedback had an adverse effect on their performance of the experimental tasks involving kana. If this supposition is correct, we could then account for Sasanuma and Fujimura's result as reflecting a difference at the level of linguistic awareness, without hypothesizing that there are two fundamentally different kinds of primary linguistic activity associated with the two Japanese writing systems.

Let us now try to summarize our experimental result and the interpretation we have offered. We found that even though Japanese kanji characters have no overt phonetic structure, they are harder for native speakers to recall correctly when the set of characters to be remembered have phonetically similar readings. We took this to mean that phonetic short-term storage depends not on the type of writing system from which the stimuli are taken but on the linguistic nature of the task: phonetic short-term storage is necessary to primary linguistic activity. Such activity must require time, and phonetic short-term storage may serve as a kind of buffer in which sentences can be represented while linguistic processing goes on. The various types of writing system, on the other hand, reflect the fact that reading and writing are secondary processes that exploit the speaker-hearer's partial and varying awareness of his primary linguistic activity.

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