Advanced frequency information and verbal response times

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Female students read aloud single words under three conditions. The words were in lists of either common words (AA), rare words (1/million), or in a mixed list of common and rare words. Naming was faster for common than for rare words. Time to name both common and rare words was about 70 msec faster in the homogeneous lists than in the mixed list, suggesting that knowledge of word frequency in advance speeds processing by a constant amount. Also, naming took longer for two-syllable than for one-syllable words. The results are discussed in relation to Oldfield's two-stage model of object naming, which receives only partial support. It is suggested that speed of search through the putative "word store" may hitherto have been greatly underestimated.

Oldfield (1966) has suggested that the recognition of a word, or word-related object or picture, is a two-stage process. First, he supposes, sufficient information is extracted from the stimulus to ascribe it to a frequency class. Then a search is carried out through the section of the "word store" (or "neural dictionary") pertaining to that class until the target item is located and can be activated to occasion a response of recognition or verbalization. This process would require the rapid evaluation of masses of disjunctive cues to word frequency which are of very low partial validity. While such features as word length, initial letter, and transition probabilities vary probabilistically with frequency, it is hard to envisage a discrimination function based on these features which could reliably allocate items to rather narrow frequency classes in an interval somewhat less than a verbal reaction time. In view of this, it seems desirable, before seeking to clarify such a problematical process, to determine if the frequency information Oldfield supposes to be extracted in his first stage can actually be used to reduce the verbal RT when that information is provided in advance. If it cannot, any experimental attack on the first stage would seem redundant.

In the present study, uncertainty about the frequency class of each stimulus was manipulated by presenting the same items in two types of serial context: one in which some of the other items were of quite different frequency in English and one in which they were of similar frequency. In addition, verbal RTs for mono- and bisyllabic words were compared as a direct check on a prior finding, based upon a partial correlation procedure, that verbal RT

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is independent of word length (Oldfield & Wingfield, 1965). Such independence of RT from the number of letters or syllables in the response item is critical for inferences drawn from differences in RT between common and rare items, in particular for estimates of rate of search through the putative "word store."

METHODS AND PROCEDURE

English words in lowercase type and without initial capitals were presented singly on cards in a Gerbrands tachistoscope with an exposure time of 1.1 sec.

There were three sets of words, corresponding to three experimental conditions: common (AA in Thorndike-Lorge); rare (1/million); and mixed (equal numbers of common and rare). Each list contained 12 words.

The words were selected at random from Thorndike-Lorge (1944) with the following constraints: (1) Neither homogeneous list had more than one word with a given initial letter. (2) Six of the words in each list had one syllable, the other six had two syllables. (3) The individual common and rare items were paired with an item in the other homogeneous list, being matched simultaneously for initial letter and number of syllables. (4) Average number of letters per word was equated between the homogeneous lists as far as possible (4.8 and 5.0 letters for the key words in the common and rare lists, respectively).

Six words in each of the two homogeneous lists were designated key words. These also appeared in the mixed list, in the same serial positions as in the other lists. The remaining positions in the mixed list were filled according to the above constraints.

Fifty-six young women from an introductory psychology pool (ages 18 to 28 years) were allocated at random to the three conditions. They were

told their items were "common," "rather rare," or "mixed (that is, common and rare words)," as appropriate. To familiarize them with the type of material they would encounter, they were first required to read aloud a list of 12 words of similar frequency of occurrence, length, and number of syllables to those in the experimental list. They then had 12 naming trials without other prior practice.

Verbal response times were read on a Hunter timer to the nearest millisecond, the timer being stopped by means of a throat microphone and voice key. S triggered the onset of each word by pressing a Morse key when ready. The word appeared instantly, supplanting a preexposure field in which the extreme left position of the word was indicated by a small cross. Ss were told to name the words as quickly as possible without making any mistakes. An S's data were accepted only if there were no errors on the key words, and not more than one misreading or correction of nonkey items.

RESULTS

Seven Ss were dropped because they did not meet the criterion of accuracy, and one was dropped because of a defective relay during recording. Error rates for the remaining 48 Ss did not exceed 1.75% in any condition. Mean latencies of response for the key words under the different conditions are shown in Table 1.

Responses were faster in homogeneous contexts than in mixed contexts. The differences, assessed by means of Mann-Whitney tests using the individual means, were statistically significant for both the rare and common words ($p < .02$ and $.05$, respectively).

Responses were faster to common words than to rare ones. The differences here were significant within the mixed group (sign test, $p < .001$) but did not quite reach significance between the two unrelated homogeneous groups (Mann-Whitney, $0.1 > p > .05$).

Figure 1, which shows the mean RTs to the individual key words, illustrates both of the above effects. In addition, it shows that two-syllable words tended to take longer to name than did single-syllable words. This difference was assessed first of all for the common and rare groups separately by comparing the individual means, each based on three words, for responses of a given number of syllables. The large-sample Wilcoxon procedure (Siegel, 1956, p. 79) yielded z values for these data of 1.67 and 2.10 for the two groups. The independent outcomes, with probabilities of .04525 and .01790,

Fig. 1. Mean median RT for naming words as a function of serial position in lists. Open circles: one-syllable words; filled circles: two-syllable words; continuous lines: homogeneous lists; broken lines: mixed lists.

respectively, were then combined by a method due to Fisher (1925, 21:1) to yield a value for χ^2 of 14.14 with 4 df ($p < .01$).

DISCUSSION

The results are pertinent to three aspects of Oldfield's (1966) paper: the notion of exploiting frequency information to limit search through the word store, the role of motor preparation in verbal RT, and inference of speeds of search through the store from functions relating RT to word frequency.

On the first point, Oldfield's position is clearly supported by the dependence of RT on list homogeneity. If S knows a word's frequency class in advance, he can, it seems, limit his search through the store to words of similar frequency or degree of familiarity. That responses to common and rare words were slowed to a similar extent by mixing frequency classes implies that a fixed time (around 70 msec) may be required to determine frequency and initiate the search. On this evidence, Oldfield's two-stage process remains quite tenable. Since initial letters and

word lengths were controlled, it seems the first stage would need to be extremely sensitive to differences in transitional probabilities between letters in words of different frequencies.

The present results do not, however, confirm the independence RT from the number of syllables in a word. RTs were reliably slower for bisyllabic than for monosyllabic items. That number of syllables rather than word length is the major factor is suggested by the fact that RTs were not evidently slower for longer two-syllable words like "manner" and "mallard" than for shorter ones (see Fig. 1). It therefore appears that Ss did not initiate partly prepared utterances, and that articulatory preparation contributed additively to RT after search for an item was completed.

Table 1
Mean Verbal Latencies (Msecs)
for Key Words

	Unmixed Lists		Mixed Lists	
	Common	Rare	Common	Rare
RT	586	658	652	740
(N)	(10)	(19)	(19)	

Finally, the data shows large quantitative divergences from that of Oldfield & Wingfield (1965), in which Ss gave concrete noun responses to drawings of objects. In both studies the mean RT to common items (A or AA) was about 600 msec, a value also obtained by Kiss¹ for verbal RTs to Oldfield and Wingfield's items in printed form. The divergencies in these studies relate to the rare items. Thus, whereas Oldfield and Wingfield's Ss responded about 600 msec slower to one-per-million words than to common words, the differences in the present case were 64 and 88 msec for the homogeneous and mixed conditions, respectively. Kiss's data give a corresponding value of between 100 and 200 msec. Since in the Oldfield and Wingfield material the rare items tended to have more syllables than the common ones, it seems reasonable to suggest that the difference between Kiss's and the present data might be due to the syllable effect described above. The larger divergence between the present data and Kiss's, on the one hand, and Oldfield and Wingfield's, on the other, is probably to be attributed to an additional process of verbal encoding of the pictorial forms used by the latter. Somewhat supportive of this view is the fact that Briggs & Swanson (1969), also using verbal responses to pictorial forms (geometric shapes), obtained estimated rates of search through storage of about 13 bits per second, close to Oldfield and Wingfield's estimate of around 17 bits per second. If the implications of the present study are correct, these values might represent underestimates of the search rate by a factor of between 5 and 10.

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NOTE

- 1. Kiss, G., personal communication, 1969.