Some linguistic determinants of word classification times*

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Ss were asked to judge, and to indicate by pressing one of two keys, whether or not tachistoscopically presented strings of letters were words. RTs were collected for actual, possible but nonoccurring, and impossible English word stems, and prefixed and suffixed versions of each kind. Ss were slowest to reject possible stems, fastest to accept real stems, and intermediate to reject impossible stems. Affixation increased RT for actual and impossible words but did not affect RT for possible ones. The results are interpreted within the framework of a two-stage phonological-semantic processing model.

The present study is concerned with the following problem: By what process does a person decide whether a printed string of alphabetic characters is, or is not, a word in his language? Clearly, the information needed to answer this question resides in the individual's memory representation of the language in his long-term memory. Moreover, various positive and negative answers might require tapping different levels of this linguistic information. For example, saying no to a string excluded from the language's sound (and spelling) pattern¹ would not appear to require the same information as saying no to a phonologically possible string having no definition. While the first might be rejected as not being projected by the language's morpheme structure rules (Chomsky & Halle, 1968), the latter would probably require a memory search for a corresponding meaning. Similarly, saying yes to all actual words might require such a memory search, but the search might be briefer if the string were a stem word than if it were formed by combining a stem word with some grammatical or derivational affix.

It is of interest whether different levels of linguistic information can be accessed in memory independently of each other, for, if they cannot, then obtaining information at one level may presuppose previous information processing at some other level. For example, Norman (1970) has suggested that preprocessing of a stimulus string such as "mgdptzy" could lead to its rejection as an English word because it is impossible

phonologically, whereas rejecting the string "mantiness," a form which is possible but does not occur, would require an additional search for its meaning. Only after no meaning is retrieved will "mantiness" be rejected. If such hypothetical processing stages occur in measurable amounts of time, then the question of serial processes in word classification can be investigated using a reaction time (RT) paradigm.

Several investigators have studied the question of whether classification of a phonologically possible word requires the retrieval of meaning. Rubenstein, Garfield, & Millikan (1970) found that classifying English words as words was faster than classifying possible but nonoccurring words as nonwords. Furthermore, homographs (lexically ambiguous words) were reacted to faster than nonhomographs, and high-frequency words faster than low-frequency words. These results were taken as support for the notion that recognizing a string of letters as a word does involve retrieving its meaning; and, presumably, recognizing a string as a nonword requires a more exhaustive and time-consuming search for a definition. Meyer & Ellis (1970), on the other hand, concluded that a decision about whether a letter string was a word was made independently of a decision about its meaning and that both processes occurred in parallel. They found that deciding whether a word was a member of a small semantic category took less time than deciding whether it was a member of a large semantic category, suggesting a search process through the exemplars of each category. However, deciding that a string was a word took no longer than deciding it was a member of a semantic category, suggesting that the process of word classification does not depend upon search and retrieval of meaning, since the set of all words is larger than the

set of words within any large semantic category.

In the present study, Ss were presented with letter strings that were actual English words, possible but nonoccurring English words, and impossible English words. Forms of these words with derivational prefixes or suffixes were also employed. A two-stage serial processing model, such as the one proposed by Norman, would predict that RTs should be fastest for impossible strings, intermediate for English words, and slowest for possible strings. If extra processing time is required for affixes, then affixed versions of all three kinds of strings should have longer classification times than nonaffixed forms.

SUBJECTS

Twenty undergraduate students at New York University, of whom six were female, were recruited by announcements in psychology classes promising payment for participation in an experiment. All were right-handed.

MATERIALS

The stimuli were 64 letter strings constructed to fall into one of nine classes. The number of stimuli in each class, the nature of the class, and an example for each are as follows: (1) 16 English stems—*hard*; (2) 8 possible English stems—*dilt*; (3) 8 impossible English stems—*btul*; (4) 8 English stems plus suffix—*hardness*; (5) 4 possible stems plus suffix—*diltness*; (6) 4 impossible stems plus suffix—*btulness*; (7) 8 English stems plus prefix—*preschool*; (8) 4 possible stems plus prefix—*prestul*; (9) 4 impossible stems plus prefix—*prebkdut*. All stems were monosyllabic. Each type of stem was used alone and in either a prefixed or a suffixed version. Four prefixes and four suffixes were combined with each type of stem. The three types of stems were approximately equal in length.

Two 32-item lists—List A and List B—were made up, such that only one string with each basic stem appeared in each. In addition, a list of nine practice words, consisting of one example of each of the classes, was made up from stems different from those on the experimental lists. The order of the stimuli was randomized within each list. Exactly half of the items in each list were English words (Classes 1, 4, and 7).

APPARATUS

The stimuli were typed onto a tape and presented via a Gerbrands two-channel Harvard tachistoscope, Model T-IC-3. The S was seated at a table and viewed the stimulus presentations through a viewing hood. The blank field contained a lighted cross which served as a fixation point. The E was seated on the other side of

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Table 1
Mean Correct RTs and Standard Deviations Across Ss (Milliseconds) and Mean Error Rates (Percent) for Each of the Categories of Letter Strings

		Prefix + Stem	Stem	Stem	Stem + Suffix
English	Mean	741	573	584	645
	SD	130	104	97	122
	Error	15.0	1.2	3.1	4.4
Possible	Mean	742	752	798	790
	SD	120	131	166	126
	Error	2.5	11.2	21.2	15.0
Impossible	Mean	700	616	626	655
	SD	116	106	118	122
	Error	0	1.2	2.5	6.2

the table and actuated the stimulus presentations, recorded the time, and advanced the paper tape on which the stimuli were typed. Each stimulus was presented for 1.1 sec, which generally exceeded S's RT to it. The S was provided with two standard telegraph keys with which to record his choice as "Yes, it is a word" or "No, it is not a word." RT was recorded to the nearest millisecond on a Hunter KlocKounter.

PROCEDURE

Each S participated in a single experimental session consisting of 73 trials, of which 9 were practice and 64 were experimental. All Ss received both List A and List B, half in the order AB and the other half in the order BA. Half of the Ss used their right hands to respond "Yes" and the other half used their left hands. The payoffs were designed to encourage both speed and accuracy; Ss were paid a base rate of \$1.50 and, in addition, earned 2 cents for each response less than 800 msec and lost 10 cents for each error. The S was informed whenever he had made an error.

RESULTS

Presented in Table 1 are mean RTs for correct responses, along with the standard deviations of the RTs. The SDs are those of mean RTs for each category of stimulus type across Ss and, as such, reflect the large individual differences usually exhibited by relatively naive Ss in the absolute magnitude of their RTs. The statistical analyses were within-S analyses, since each S received each category of stimulus, and so are more sensitive to differences among the categories of stimuli with individual differences removed than are reflected in the relatively large SDs shown for each mean RT. The error rates for each category of lexicalness and each affixation condition are also shown in Table 1. The stem and stem plus affix conditions are in paired groups having identical stems. Considering first the error rates, the overall error rate was relatively high (6.7%) and approximately equal for words and nonwords (5.9% and 7.5%,

respectively). However, error rates differed considerably among the various conditions, and possible letter strings showed the highest overall error rate. Affixation seemed to decrease errors for these possible words but increase it for impossible and actual English words.

A similar pattern is apparent for the RT data: possible words showed longer RTs than either impossible or actual English words. While affixation increased RT for English and impossible stems, it appeared to decrease RT slightly for possible stems. The increase in RT caused by affixation for English and impossible stems was about three times as great for prefixes (about 170 msec for English and about 80 msec for impossible stems) as for suffixes (about 60 and 30 msec for English and impossible stems, respectively).

These conclusions are supported by the results of two-way within-Ss ANOVAs performed separately on stems and prefixed stems and on stems and suffixed stems. Factor A was degree of lexicalness and Factor B, affixation. For stems and prefixed stems, both main factors and their interaction were significant beyond the .01 level ($F_A = 26.35$, $df = 2/59$; $F_B = 219.35$, $df = 1/39$; $F_{AB} = 48.76$, $df = 2/119$). For stems and suffixed stems, Factors A and AB were significant beyond the .01 level and Factor B beyond the .05 level ($F_A = 103.35$, $df = 2/59$; $F_B = 6.93$, $df = 1/39$; $F_{AB} = 6.04$, $df = 2/119$).

By post hoc *t* tests, all differences among RTs for stems were significant beyond the .025 level. Thus, English stems were accepted as words faster than impossible stems were rejected, and the latter were rejected faster than possible stems.

DISCUSSION

It is clear that both linguistic variables studied, degree of lexicalness and affixation, are strong determinants of word classification time and that they interact with one another. The fastest RTs were obtained for accepting actual words, nearly as fast RTs for rejecting impossible words,

and the slowest RTs for rejecting possible but nonoccurring words. This pattern of results rules out a simple sort of serial processing model such as the one discussed in the introduction. If the phonological, or preprocessing, stage takes as much time for possible as for impossible forms and, additionally, meaning must be retrieved for one to conclude that a possible form is in fact a word, then RTs for actual words should be greater than those for impossible words. Unfortunately, they are not.

It is possible, however, that preprocessing time is shorter for possible than for impossible forms, just as search time appears to be shorter for actual words than for possible but nonoccurring ones. Thus, in each stage of the model, affirmative responses might be quicker than negative ones. If this assumption is made, the model can predict the pattern of results obtained for stems, although other patterns are also possible. A similar set of results for RTs to stems has been obtained by Rubenstein, Lewis, & Rubenstein (1971a, b), who also found English words faster to classify than impossible ones and the latter faster than possible words. Their conclusion was that no search for meaning was needed to reject impossible forms and that the phonological stage (in their model the quantization stage) must require more time for impossible than for possible English.

If the affixation effect obtained is reliable, however, then syntactic information about lexical items may also partly determine word classification decisions. Affixation delayed affirmative decisions on actual words, to a lesser extent negative decisions on impossible forms, and for both these kinds of stems, added about three times as much time for prefixes as for suffixes. For possible but nonoccurring forms, however, affixation reduced errors and had no apparent effect on RT. These effects may be partly a function of the approximation of letter strings to English (where ambiguous items are most difficult), but a nongrammatical length interpretation of them is ruled out in this case, since the three stem types were about equally long and the prefixes and suffixes used with each were identical. In fact, mean string length was not significantly correlated with mean RT (Pearson $r = +.28$ across the 12 conditions shown in Table 1).

If more preprocessing time was required to phonologically determine the longer affixed forms, affixation would need to have also had a second effect on word classifications. This added effect would presumably result from the information affixes provide

(about word class, etc.). Generally speaking, such additional linguistic cues would need to simplify the classification of possible words with respect to actual ones. This might occur in at least two ways. On the one hand, affixation might be considered simply to decrease semantic search time for possible words but to increase it for actual ones. Alternatively, affixation might be viewed as adding, or making apparent, an (intermediate) syntactic processing stage and reducing semantic search time to a greater extent for possible than for actual words. Looked at in either way, the effect of affixation obtained might be taken to support some notion of a partly derived internal lexicon

(Kintsch, 1972; Gibson & Guinet, 1971).

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NOTE

1. Following Chomsky & Halle (1968), it is assumed that a reasonably close correspondence exists between certain English spellings and their lexical representations at an abstract phonological level.