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ABSTRACT

In three immediately succeeding trials, 45 young adults named 50 pictures of objects as rapidly as possible; word retrieval latencies were measured for each item. Before each trial, one experimental group was given information as to the word frequency (WF) level of the items' names. The other experimental group was given information as to the typical age of acquisition (AOA) level of the names; the pictures and names had been selected such that the WF and AOA had a low correlation. Under all conditions, AOA was a stronger predictor of latencies, or response time, than WF. Scores on a psychometric test of speed of picture naming were highly correlated with mean reciprocals of latencies in the experimental picture-naming situation. Priming of responses by prior information on AOA was more facilitative than WF information, but as compared to the control condition such information had a retarding effect. Speed of naming improved over trials in all conditions, but AOA level of the names, as well as the lags between successive presentations of an item, affected the amount of improvement in a complex manner. Retrieval of an item from truly long-term memory appeared to place it in an immediate memory buffer. (Author/MV)

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WORD RETRIEVAL LATENCIES AS A FUNCTION OF FREQUENCY AND AGE-OF-ACQUISITION PRIMING, REPEATED TRIALS, AND INDIVIDUAL DIFFERENCES

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ABSTRACT

Over three immediately succeeding trials using different randomized orders of stimuli, 45 young adults, mostly males, named 50 pictures of objects, each as rapidly as possible; latencies were measured for each item. Fifteen of the subjects were tested in a control condition; before each of 5 blocks of 10 items in a trial, subjects in a second group (N = 15) were given information as to the word frequency (WF) level of the items' names, and a third group (N = 15) were given information as to the typical age of acquisition (AOA) level of the names, the pictures and names having been selected such that the WF and AOA levels had a correlation as low as possible. Under all conditions, the previous finding (Carroll & White, 1973a) that AOA was a stronger predictor of latencies than WF was confirmed. Scores on a psychometric test of speed of picture naming were highly correlated (within-group r = .69) with mean reciprocals of latencies in the experimental picture-naming situation. "Priming" of responses by prior information on AOA was more facilitative than WF information, but as compared to the control condition such information had a retarding effect. Speed of naming improved over trials in all conditions, but AOA levels of the names, as well as the lags between successive presentations of an item, affected the amount of improvement in a complex manner. It is suggested that retrieval of an item from TLTM ("truly long-term memory") places it in an immediate memory buffer.

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Speech production in daily life and conversation seems to be highly automatic. Only occasionally does a speaker experience any difficulty, or have to make any effort, in the process of finding words and formulating sentences to express the concepts and ideas he wants to convey. A moment's reflection, however, reveals that the apparent automaticity of speech production is very mysterious. Even if we leave aside the question of how one learns to produce grammatically acceptable sentences with great ease and fluency, we still find it remarkable that, given some concept that one wishes to find a word for, one can usually call up from memory, quite effortlessly, that particular one of some tens of thousands of lexical items that is needed to express the concept. This mysterious process of word retrieval and the properties of the "truly long-term memory" (TLTM) where representations of lexical items are presumably stored seem to call for scientific study, as an important part of the general effort to understand how the mind works and as a basis for developing educational and clinical procedures for dealing with word-finding difficulties in children, aphasics, and other groups. Such scientific study must usually be done in experimental settings in which stimulus presentations can be controlled and responses well observed and measured.

One such experimental setting is the picture-naming task, in which subjects are presented with pictures of nameable objects and required to utter the conventional name of the object as rapidly as possible. Although this type of task was used in early studies of reaction time (Cattell, 1885), it is only in recent years that serious attempts have been made to delineate the variables that control the naming response and to understand the nature of the retrieval process. Oldfield and Wingfield (1965) found that names (words) that occur in large samples of speech or writing with high frequency are retrieved faster than names that occur less frequently, but Carroll and White (1973a, 1973b) have obtained results suggesting that the controlling variable is not so much the frequency with which the name occurs but rather the age at which the name is learned by the individual. Names that are typically learned early in life are retrieved faster than names learned later in life. This conclusion has been confirmed by Lachman, Shaffer, and Hennrikus (1974), even to the extent of showing that the relation holds best when age of acquisition of names is measured for particular individuals. These investigators have also studied other variables such as stimulus codability, trials, and individual differences, all of which appear to influence speed of naming.

The present study has been designed to clarify some of the reported functional relationships and to explore further what the results imply concerning retrieval from TLTM. The previous studies by the writer (Carroll & White; 1973a, 1973b) were not explicitly designed to examine the relative contributions of word frequency (WF) and age of acquisition (AOA); the AOA variable turned up as a post hoc variable that appeared to account for latency variance not accounted for by the WF variable. Therefore, in the present study an attempt is made to vary WF and AOA separately in order to confirm that the effect of AOA is independent of any effect arising from WF.

More fundamentally, however, this study addresses questions about what processes or mechanisms may be involved in word retrieval. From research on the so-called "tip of the tongue' (TOT) phenomenon (Brown & McNeill, 1966), it is known that prior to retrieval of a word corresponding to some distinct internal representation of a concept as conveyed by a definition, a subject can experience awareness of the fact that he has that word in his lexicon even though he cannot immediately retrieve it. He can also experience, with some accuracy, awareness of certain attributes of the word sought, such as its length (in syllables), its accentuation, and some of its phonetic properties (e.g., its initial phoneme). Brown and McNeill suggest that these word attributes may serve as keys or templates for search of the lexical store, as if the subject uses them to address particular partitions of this store.

WF and AOA might also serve as functional word attributes in a memory search. Subjects are able to judge words fairly accurately with respect to WF (Carroll, 1971) and AOA (Carroll & White, 1973b), and it must therefore be concluded that words can be experienced as having properties with respect to their frequency in general usage and with respect to the approximate period of one's life at which they were acquired. The fact that the accessibility of a word (as indexed by the reciprocal of its latency in a picture-naming task) is a function of either its WF or its AOA, or both, suggests that the lexical memory story may be organized or partitioned with respect to either or both of these variables. It is possible, therefore, that a subject's being given prior knowledge of the WF or the AOA attribute of a word he is to retrieve would facilitate or "prime" that retrieval, by allowing the subject to address a particular portion of his lexical store. The present study was designed to investigate this possibility, and to determine which of the two variables--WF and AOA--would be the more effective priming attribute. In view of previous results (Carroll & White, 1973a, 1973b) it was predicted that AOA would be the more effective priming attribute.

The study was also designed to investigate how the WF and AOA variables might

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interact with processes whereby words recently accessed from TLTM can be retrieved faster upon a second or third presentation of an appropriate pictorial stimulus.

Finally, the study reflects an interest in what types of individual difference variables are associated with parameters of word retrieval processes. Measures of speed in naming pictures, colors, forms, etc., appear to be correlated in such a way as to define a distinct factor of cognitive ability, the Naming factor identified by Carroll (1941; see also French, 1951). A similar factor, identified as "factor X_3," appears in a study by Thurstone and Thurstone (1941). The question arises whether measures of the Naming factor obtained in group testing settings would be correlated with measures of picture naming latencies obtained in experimental settings. Also, if it could be established that there are reliable individual differences in picture-naming latencies (reliable, that is, in the sense of being generalizable over a set of stimuli) it might be revealing to determine whether these individual differences are correlated with individual differences in various other kinds of perceptual and verbal tasks.

Method

The basic task was one in which a picture of an object or type of person is projected from the rear on a screen in direct view of the subject; the subject is asked to give the name of the thing represented as rapidly as possible. The latency of response is measured as the time, to the nearest .001 sec., from the initial presentation of the picture to the triggering of a voice key placed about 10 cm in front of the subject's lips. Immediately upon the triggering of the voice key, the projection of the picture terminates and the screen reverts to darkness.

The pictures used in this study were colored slide photographs (not line drawings as used in the earlier study) either of actual objects or of pictures found in magazines, children's books, and the like. An effort was made to select pictures such that the objects to be named would be highly recognizable. Cn the screen, the projected size of pictures was approximately 27 cm (horizontal) by 18 cm (vertical); a few pictures appeared with the longer dimension on the vertical. The subject was seated so that his eyes were level with the screen at a distance of approximately 35 cm. The time between successive slides in a particular series was about 8 to 15 seconds--enough to permit the experimenter to record the subject's response and the latency (read from a digital timer connected to circuitry involving the voice key and a photocell that detected when projection of a picture began.) If a response did not occur within 10 seconds, it was regarded as invalid.

The experiment used 50 pictures of objects (or types of persons, e.g., JUGGLER) whose names were selected from Carroll and White's (1973b) norms in such a way that there would be 10 names at each of five levels of the WF variable and also 10 names at each of five levels of the AOA variable, with the WF and AOA indices as orthogonal to each other as possible. The WF indices used in selecting words were those listed under the A-H (American Heritage) column of the norms. Since it was intended that most subjects would be male, the AOA indices used were those listed under "Male Ratings" in the norms. (The "Male Ratings" are, however, highly correlated with the "Female Ratings" and hence are not inappropriate for female subjects.) Table 1 displays the placement of the names in the resulting 5 x 5 matrix. Ideally, it would have been desirable to fill each cell of this matrix with exactly two names, and thus to make the correlation between

Insert Table 1 about here

WF and AOA essentially zero, but this proved to be impossible on the basis of the norms used. The norms list few if any words that are learned early in life and yet are of low frequency; likewise, they list few words that are learned recently and yet are of high frequency. With respect to WF, the

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distribution of words was truncated; no word has an A-H SFI rating (Carroll, 1970) greater than 57.1 (occurrence frequency about 50 per million). In the analysis of data, all six AOA and WF indices listed in the norms were considered; Table 2 gives the intercorrelations of the six indices over the 50 words, together with the corresponding values for all 220 words in the norms. The negative correlations between AOA and WF result from the way in which these variables are measured; words learned early (low AOA indices) tend to have higher frequencies (high WF indices) than words learned later. In view

Insert Table 2 about here

of the limitations of the norms, the relatively low absolute magnitude of the correlations between WF and AOA indices was gratifying in terms of the design of the experiment.

Since the study was not concerned with the effects of stimulus uncertainty in the sense defined by Lachman, Shaffer, and Hennrikus (1974), an effort was made to select pictures for which a large majority of the subjects would give the same name, if they were able to name them at all.

Subjects were given three trials in which to name the 50 pictures; each subject had a different randomized order of stimuli. To minimize inconvenience in loading slides into the Kodak Carousal projector, the order of the stimuli in the Trial 3 list was exactly the reverse of that for the Trial 1 list. The trials were separated by a short rest period. Subjects were informed that there would be a further trial, after Trial 1 or 2, only after that trial was completed.

Three conditions were used in a between-subjects design: (1) a control condition (N = 15) in which the subject was asked simply to name the objects or things pictured; (2) a WF-primed condition (N = 15); and (3) an AOA-primed condition (N = 15). All subjects in the control condition were run in advance of the running of subjects in the two other conditions, but subjects in these two latter conditions were assigned to conditions alternately as they appeared. For the two experimental conditions, the stimuli in each trial were divided into five blocks of 10 pictures each, corresponding to one of the five levels of the WF or AOA variable. The order in which these blocks were presented was counterbalanced over subjects and trials. Subjects in the WF-primed condition were told, before the trials began, that the experimenter was interested in seeing whether the speed of naming was affected by the subject's prior knowledge of the frequency level of the name to be given; in the AOA-primed condition, they were told that the experimenter was interested in seeing whether speed of naming was affected by the subject's prior knowledge of the AOA level of the name to be given. Thus, prior to each block of 10 stimuli the subject was told that he would be seeing pictures of items whose names were of a given WF or AOA level; he was given characterizations of these levels and examples of words at these levels that were drawn from the Carroll and White (1973b) norms but not used in the stimulus sets themselves.

Following are the sets of characterizations of WF and AOA levels, and words at those levels, that were shown to subjects (on index cards) prior to presentation of the corresponding series of stimuli. This information was furnished to the subjects not only in Trial 1 but also in Trials 2 and 3, to refresh their memories. Subjects were allowed to study this material as long as they wished; generally they took less than a minute to do so. This meant, of course, that the trials in the WF-primed and AOA-primed conditions took longer than those in the control condition since they included presentation of the priming materials.

WF-primed condition:

Level 1: Relatively rare words: CHEF, BLENDER, PONCHO, MAYPOLE, TIGHTS

Level 2: Somewhat infrequent words: PIZZA, HOURGLASS, BAGPIPE, BANISTER, SCORPION

Level 3: Words of "average" frequency: BLOUSE, OCTOPUS, HOAGIE, STAGECOACH, FINGERPRINT

Level 4: Somewhat common words: SKULL, STRAWBERRY, ENVELOPE, SCREW, GUITAR

Level 5: Fairly common words: TENT, GLOBE, VOLCANO, FAN, FIREPLACE

AOA-primed condition:

Level 1: Words learned on the average around ages 9 or 10, or 4th to 5th grade level, or even more recently: BAROMETER, LEOTARD, SYRINGE, FLASHCUBE, HIPPIE

Level 2: Words learned on the average around ages 7 or 8, or 2nd to 3rd grade: BUGLE, SPOOL, MOTEL, BLACKSMITH, GLACIER

Level 3: Words learned on the average around age 6, or at the 1st grade level: WIGWAM, CACTUS, DICE, KANGAROO, PEACOCK

Level 4: Words learned on the average around age 5, or in kindergarten: NUN, CIGARETTE, HORSESHOE, BEAVER, MACARONI

Level 5: Words learned on the average around ages 3 or 4, or in nursery school, or even earlier: LEMON, TURTLE, LADDER, FISHERMAN, BICYCLE.

To the extent possible, the examples selected for each WF level varied in AOA, and the examples for each AOA level varied in WF.

Prior to Trial 1, all subjects (in control and experimental conditions) were given five pictures to name for practice (APPLE, BAROMETER, PIZZA, TENT, TELEVISION), without any special instruction other than to give the names as rapidly as possible.

Psychometric tests. In order to obtain individual difference information that could be correlated with performance in the basic picture-naming task, each subject was given six tests, described below, either in the same session as the individual picture-naming task or in a separate testing session in which up to 10 subjects could be tested simultaneously (but in any case, always after the subject had served in the picture-naming task). The first five of these tests were group-administerable tests taken from the Kit of Reference Tests for Cognitive Factors assembled by French, Ekstrom, and Price (1963).

1. Hidden Figures. This is purported to be a test for factor CF, Flexibility of Closure. Each item requires the subject to indicate which of five geometric shapes (presented at the top of the page) is embedded in a more complex design. There are two separately timed parts, 10 min. each, with a total of 32 items, scored by the formula (Rights minus Wrongs/4), not counting Omits.

2. Thing Categories. This is claimed to be a test of factor FI, Ideational Fluency. There are two separately timed tasks, 3 min. each; in the first of these, the subject is required to write as many examples as he can think of, in the time allowed, of "things that are round or that are round more often than any other shape"; the second part asks for examples of "things that are always blue or that are blue more often than any other color." The score is simply the total number of examples written in the two

parts, with no attempt to evaluate their appropriateness (but with elimination of clear duplicates).

3. Controlled Associations. A test claimed to measure factor FA, Associational Fluency. It contains two separately timed parts, 6 min. each; part 1 asks for as many examples as possible of words that "have meanings which are the same as or similar to" each of the following words: clear, dark, strong, wild; part 2 asks for words semantically similar to: company, sharp, tell, and turn. The score is the total number of words written.

4. Gestalt Completion Test. This is reported to measure factor CS, Speed of Closure. There are two separately timed parts, 3 min. each, containing a total of 20 items, each requiring the subject to write the name or description of a picture that is presented in incomplete or fragmentary form. The score is the number of pictures correctly described.

5. Advanced Vocabulary Test. This is a measure of factor V, the "verbal factor" that reflects the extent of the subject's general lexical knowledge. It has two separately timed parts, 4 min. each, with a total of 36 generally difficult multiple-choice vocabulary items. The score is obtained by the formula (Rights minus Wrongs/3).

6. Picture Naming. This test was developed by Thurstone and Thurstone (1941). It consists of three pages of small line-drawings of common objects, arranged in seven rows of seven pictures each on a page. As used by the Thurstones, the subject was required to write the first letter of the name of each object in a space immediately below the object, the score being the number of first letters written in two minutes. As used in the present study, however, the test was individually administered; the subject was told to name the pictures as rapidly as possible, and the score

was the number of pictures that were named, orally, by the subject in 60 sec., moving across rows and down each page.

The reason for including Test 6, Picture Naming, has already been stated. The other tests were included to represent various hypothesized aspects of the picture-naming task. An intuitive analysis of performance on Test 1 (Hidden Figures) suggests that it depends on an ability to perceive a spatial concept as a figure with respect to an interfering or distracting context or ground. The test was included in order to explore the possibility that the picture-naming task involves a similar ability to identify a lexical concept (a word) within the context of a large number of other concepts in the lexical store. Test 2 (Thing Categories) and Test 3 (Controlled Associations) represent different types of lexical search; they were included in the battery in order to see whether speeds in either of these types of lexical memory search would be found to be correlated with speed in the kind of lexical memory search involved in picture naming. Test 4 (Gestalt Completion) can be regarded as representing a search of a store of pictorial images; one could entertain the hypothesis that speed in this type of memory search is correlated with speed in lexical search. Finally, Test 5 (Advanced Vocabulary) was included for several reasons: (1) general vocabulary knowledge might reflect a greater facility in retrieving words because the words are more available; (2) on the other hand, if it is assumed that picture naming involves a serial scan of lexical memory, it could be the case that high-scoring subjects would take longer to retrieve words than low-scoring subjects because the former have a larger lexical store to search; (3) low scores might explain subjects' inability to retrieve names for some of the pictures as reflecting a low probability that these words existed in their verbal repertoires.

Subjects

The fifteen subjects in the control condition, and the first six that were run in the two experimental conditions, were young adult males who (except for two research assistants volunteering at Educational Testing Service) were obtained by advertising among students at Princeton University. Because of certain difficulties in continued drawing from this source, the remaining 24 subjects included three more research assistants and 21 persons obtained by advertising among students at Rider College and Trenton State College; 18 of these were males and six were females. The groups for the three conditions were well matched in mean age (about 22 years); there were 12 males and three females in each of the experimental conditions. One female subject had to be replaced with another because she had an excessively small number of valid responses in the picture-naming task (less than 31 on each trial). All subjects (other than research assistants) were paid $5 to $10 for participation and transportation.

Results and Discussion

Apparently because of the different sources used, the subjects in the control group were not well matched to subjects in the experimental conditions. As may be seen from Table 3, the subjects in the control condition were generally superior to the remaining subjects on the psychometric tests, significantly so ($p < .01$) on Hidden Figures, Controlled Association, and Advanced Vocabulary. The means for the two experimental groups, however,

Insert Table 3 about here

were not significantly different on any of the tests; subjects in these groups had been randomly assigned to conditions (by alternate assignment as they appeared).

In the picture-naming task, instrumental and other difficulties made for some loss of data. Occasionally the digital timer, photocell, or voice key failed to operate properly. Despite instructions to the contrary, subjects sometimes voiced a preparatory "uh" or similar sound before giving a response, thus triggering the voice key prematurely. Subjects occasionally did not know the name of the object pictured, or gave a response other than what was regarded as correct. This happened most frequently on Trial 1; as trials progressed subjects giving incorrect or "don't know" responses in the first or second trial were sometimes able to give the correct response in a later trial. (No feedback or prompting was given at any time during the experiment.) Criteria for acceptance of responses were strict, the only exceptions being as follows: TUB was accepted for BATHTUB; FIREHYDRANT for HYDRANT; WATERFAUCET for FAUCET; RATTRAP or TRAP for MOUSETRAP; WATERPITCHER for PITCHER; PROP for PROPELLER; TEASPOON for SPOON; and THERMOSBOTTLE for THERMOS. Some pictures turned out not to be as uniformly codable as might have been desired; for example, the (enlarged) picture of MOSQUITO had occasional responses of ANT, BUG, BUMBLEBEE, DRAGONFLY, FLY, GRASSHOPPER, INSECT, SPIDER, or WASP, but such responses were regarded as incorrect and the data points were not used. Over the 45 subjects, valid data points (i.e., with correct responses and valid latency measurements) for fewer than 30 subjects were obtained for the following items (the numbers of valid data points are given in parentheses): ASTRONAUT (22), CALIPERS (11), MOSQUITO (22), OBSERVATORY (29), SEXTANT (20), SILHOUETTE (15). Out of the 2250 possible data points in Trial 1, 84.1% were valid (90.0% for the control condition, 79.1% for the WF-primed condition, and 83.2% for the AOA-primed condition). In Trials 2 and 3 the percentages of valid data points were 89.0% and 90.2%, respectively, over all subjects. The percentages of words on which valid data points were available on all three trials were 86.5% for the control condition, 75.9% for the WF-primed condition, and 81.0% for the AOA-primed condition, or 81.1% for all three groups. Since group differences in the validity of data points appeared to be correlated with performance on some of the psychometric tests (see below), comparisons among groups were made, where desirable and feasible, by the use of covariance analysis in which the covariates were (1) score on the Picture Naming Test, and (2) the mean AOA rating of the words for which the subject had valid responses.

Treatment of latency data. Distributions of raw latency measurements of single words over subjects and for subjects over words were found to be positively skewed, with occasional "outliers" representing very long latencies. In order to obtain more meaningful measures of central tendency than the simple arithmetic averages of raw latencies, and to produce distributions that would more nearly approximate normal distributions, all latencies were transformed to their reciprocals. Reciprocals of latencies, therefore, were employed in all analyses of data. Figure 1 shows the effect of the reciprocal transformation for the distributions of latencies of three words, BANANA, BANJO, and SEXTANT, selected to represent words with fast, average, and slow responses. Figure 2 shows the effect of this transformation for the distributions of latencies (over words) of three subjects selected to represent fast,

Insert Figures 1 and 2 about here

average, and slow responders. In each of these figures, cumulative distributions of raw latencies and then of transformed latencies are plotted on normal probability coordinates. It is clear that the distributions of transformed latencies approximate normal distributions better than those of the raw latencies. The writer does not necessarily attach any special significance to the normal distribution except for its role in the assumptions underlying various statistical techniques, but it may be of some theoretical interest that the reciprocal transformation of picture-naming latencies tends to produce normal distributions. Furthermore, reciprocally transformed latencies tend to have correlations of greater absolute magnitude with other variables that are relevant to them and that have well established metrics (e.g., logarithmically transformed word frequencies).

The means of reciprocally-transformed latencies of words over subjects were computed for each trial in each condition; the intercorrelations of these means are shown in Table 4, along with the means and standard deviations of these means. It is evident that when latencies for the 50 items studied here are averaged in this way over subjects, they are highly correlated over conditions (and thus over different groups) and (to a slightly lesser extent) over trials within groups. The means of the means increase over trials in a consistent manner over the three conditions (i.e., the responses become faster), but the curves differ from group to group. The significance of these differences is considered below.

Insert Table 4 about here

Word frequency versus age of acquisition as predictors of latencies. By varying word frequency and age of acquisition as independently as possible, the study was designed to confirm more clearly the previous finding (Carroll & White, 1973a, 1973b) that the latter variable is a better predictor of picture-naming latencies than the former. Two approaches were taken in the analysis of the data. First, correlations of AOA and WF measures with mean reciprocals of latencies over subjects were computed for each trial and each condition; the results are shown in Table 5. To make the results comparable over trials, the latencies were averaged only for words for which there were valid responses in all three trials. In every case the absolute magnitudes of the AOA correlations are greater than those for the WF correlations, although the differences do not attain significance at $\alpha = .05$. The male AOA ratings have higher correlations than the female AOA ratings, a result that is possibly (but not necessarily) associated with the fact that most of the subjects in the study were males. There were no consistent and significant differences among the several WF measures in the extent of their correlations with latencies, but they are all relatively low. There is a significant drop in all the correlations in Trial 2 for the control condition, but the meaning of this is unclear; it will be considered later. The bottom rows of the table pertain to the question of the relative contributions of AOA and WF measures. The combined male-female ratings and the Thorndike-Lorge SFI were put into multiple regression analyses for the prediction of the latencies; the correlations between the two independent variables in these analyses were -.494 in every case. (The combined male-female ratings were used rather than the male ratings because of their possibly greater reliability; in any case they are very highly correlated (r = .989) with the male ratings. The Thorndike-Lorge SFI values were used rather than the A-H values because as is seen in Table 2 they are less highly related to the AOA ratings and may thus represent purer measures of WF; the A-H values are based on a corpus of material written for young people and apparently reflect AOA to some extent, as suggested by Carroll and White [1973b].) As expected, the standardized regression coefficient for the AOA variable (labeled β_3) was in every case greater in absolute value than that for the WF variable (β_4). None of the latter coefficients was significant at $\alpha = .05$; thus, WF makes no significant added contribution to the prediction of latencies beyond what is contributed by the AOA variable. On the other hand, it may be noted that the coefficients for the WF variable are all consistently positive.

Insert Table 5 about here

Second, similar procedures were carried out for individual subjects, with results as shown in Table 6. This table shows that the absolute magnitude of the AOA correlation with latencies is in the great majority of cases larger than that of the WF correlation; further, the former correlation is in the large majority of cases significantly different from zero at $\alpha = .01$, at least for Trial 1. There is some drop in the incidence of significant correlations in Trial 2, and an upturn in Trial 3. Finally, the number of subjects for whom the WF variable makes a significant ($p < .05$) added contribution beyond the AOA variable is quite small.

Insert Table 6 about here

These results leave little doubt that age of acquisition is a better predictor of picture-naming latencies than word frequency, certainly for data averaged over subjects, and also for most individuals.

Prediction of latencies from psychometric tests. To see what kinds of abilities may be involved in picture-naming latencies, the six psychometric test scores, plus one other measure to be described momentarily, were put into multiple regression analyses for the prediction of the mean reciprocal latencies averaged over words for individual subjects. This was done both for subjects in the separate conditions and for all subjects pooled. In view of the small numbers of subjects in the separate conditions, however, and the consequent small numbers of degrees of freedom, the multiple correlations for these analyses were generally not significant even though they ranged from .659 to .952 (this last value was significant at $\alpha = .01$); consequently these detailed analyses will not be reported here.

The additional independent variable was the number of words for which a given subject had valid responses, with valid latency measurements, on all three trials of the experimental picture-naming task. This variable was included to provide a partial control of the fact that the mean reciprocal latencies being predicted were based on varying numbers of words. If anything, however, this fact would work against correlations with relevant variables, inasmuch as the words that some subjects tended to miss were generally the more difficult words, with consequently slower latencies. Thus the effect of the missing data was to attenuate the variance of latencies.

The results reported in Table 7 are those based on the pooling of subjects in all conditions. The correlations were computed, however, only after all variables were standardized within the respective groups. This rather conservative procedure, which may have represented an overcorrection, was adopted in order to allow for the significant differences among group means on the psychometric measures and for the possibility that the different conditions had significant effects on the latencies (as indeed they appeared to have; see below).

Insert Table 7 about here

In the multiple regression analyses, only the Picture Naming Test makes a significant contribution to the prediction of the latencies; this is true for the data of each trial. Although the other measures show moderate positive correlations with the latency variables, any contribution they might make to the prediction is absorbed by the Picture Naming Test. This result might be regarded as not at all surprising, for it could be argued that the tasks involved in the Picture Naming Test and in the experimental picture-naming task are highly similar, and the performances are measured in much the same way. On the other hand, there are differences: the stimuli in the Picture Naming Test are all pictures of very common objects, almost always immediately recognized and named by all subjects, while the stimuli in the experimental picture-naming task include many that are named with some difficulty in word-retrieval. The Picture Naming Test is a continuous naming task--stimuli are to be named one after another in rapid succession, while the naming responses in the experimental task are isolated responses, separately timed. In the literature of individual differences there are relatively few instances in which a psychometric measure of the same general character as the Picture Naming Test has been found to have high correlations with a carefully controlled experimental task. The indication of the present result is that picture-naming speed is a rather robust parameter of individual differences; its possible importance needs to be explored in other contexts. Picture-naming speed may, for example, be representative of some more general type of response speed. It is difficult to believe that it represents merely variation in motivation or in attitudinal set; all subjects in the present study appeared to be genuinely motivated to comply with instructions to respond as rapidly as possible, both in the Picture N...ing Test and in the experimental task. There is the possibility, of course, that picture naming speed could be manipulated by the use of special incentives.

The effect of priming through prior knowledge of WF or AOA levels of words. In the design of the study, it had been thought that a subject's prior knowledge of the WF or AOA level of the name that he was about to be required to give might be found to facilitate the response, as compared with a control condition in which such knowledge was not available. The underlying rationale for this hypothesis was that such prior knowledge might make it possible for a subject to "address" a particular portion of TLTM, rather than searching it as a whole. Oldfield (1966) speculated that searching TLTM might be a two-stage process in which the first stage would be the addressing of a portion of memory containing names of a particular frequency level. With the finding that AOA is more relevant to word retrieval, it seemed reasonable to hypothesize that TLTM might be organized in terms of AOA levels rather than WF levels. The mean reciprocal latencies shown in Table 4, however, appear to indicate that "priming" either by AOA or WF information tends to retard rather than accelerate responses; on all trials, responses were faster, on the average, in the control condition than in either of the experimental conditions. At the same time, the fact that responses were faster in the AOA-primed condition than in the WF-primed condition lent some support to the notion that memory addressing is more successful when operating with AOA information than when operating with WF information.

These conclusions, however, would disregard the fact that the mean latencies appear to be correlated with ability differences among the groups in the three conditions. The comparison between the WF-primed and AOA-conditions seemed to be fairly secure, since these groups did not differ significantly on any of the psychometric tests (or, for that matter, on the mean number of valid responses obtained over three trials), and the groups had been formed on the basis of a type of random assignment. The comparison with the control condition, however, was associated with several highly significant differences in the psychometric test means and the average AOA level of the words responded to (see Table 3). In any case, to eliminate (as much as one could) the possibility that the results were an artifact arising from unintended interactions between experimental treatments and mean ability levels of subjects in the respective treatment groups, analysis of covariance procedures were used. Since it had been found that the Picture Naming Test was an excellent and comprehensive predictor of the latency measurements, and since the mean scores on this test appeared to be correlated with the mean latencies over conditions, this was used as one of the covariates. The mean male-female-combined AOA ratings of the words for which a subject had valid responses in all three trials of the experimental picture-naming task was used as the second covariate.

The covariance analyses were performed both for individual words and for data pooled over words, using reciprocals of latencies (or means thereof) as the dependent variable. Two contrasts were considered in each analysis: (1) the contrast between the means of the WF-primed and AOA-primed groups, and (2) the contrast between the control condition and the combined experimental groups. Table 8 provides a summary of all results.

Insert Table 8 about here

In the analysis of mean reciprocal latencies for subjects over words responded to on Trial 1, covariance adjustment made for only moderate differences between unadjusted and adjusted means. Latencies for the AOA-primed condition were shown to be clearly faster than those for the WF-primed condition. At the same time, the latencies for the control condition appeared to be faster, on the average, than those for the experimental conditions combined, and for that matter, than either of the two means for the experimental conditions. If we convert the adjusted means to raw latencies, the values are 911 ms for the Control condition, 946 ms for the AOA-primed condition, and 1046 ms for the WF-primed condition. If we assume additivity of reaction times, it appears to require on the average 35 ms to process AOA information, or 135 ms to process WF information, in addition to whatever processing is required to retrieve a word from TLTM.

In the separate analyses for individual words, only one covariate was used, namely the Picture Naming test score, in order to maximize the number of degrees of freedom available for the error term. The variances of latencies over subject in the several conditions were apparently so great as to preclude the finding of significant contrasts in most instances. Nevertheless the results generally agree with those obtained for means of latencies over words. Adjusted means showed faster responses for the AOA-primed condition in nearly every comparison, and six of these were significant at $\alpha = .05$. (There were no significant comparisons for the opposite trend.) Similarly, the comparisons of adjusted means for the Control condition in the majority of cases favored the Control condition over the combined results for the experimental conditions, and all 12 comparisons that were significant at $\alpha = .05$ were in this direction.

These results suggest, then, that while prior knowledge ("priming") of AOA information is more facilitating than prior knowledge of WF information, the processing of such information constitutes an extra step in word retrieval and is on the whole retarding as compared to a control condition where no prior information is given.

One caution in the interpretation of the results must be pointed out, namely that the words in the experimental conditions were blocked by AOA or WF, whereas they were presented in unblocked, randomized order in the control condition. This blocking might in itself have produced some effect; it would have been desirable to have had additional control conditions in which the words were blocked by AOA or WF but with no reference to this blocking in the instructions to the subjects.

All these results pertain only to Trial 1 data, i.e., to latencies for the retrieval of words that, at least within the experimental setting, have not been recently accessed. It was not deemed worthwhile to pursue similar covariance analyses for Trial 2 or Trial 3 latencies, since by Trial 2 a number of other variables undoubtedly intervened, as will now be shown.

Changes in latencies over trials. On the average, responses increased in speed over trials. This was true for each of the three conditions, as may be seen from the means of mean reciprocals shown in Table 3. In each case, the increases were greater from Trial 1 to Trial 2 than from Trial 2 to Trial 3. There were no striking differences among conditions in the shapes of the curves. Since only three trials were given, it is not possible to estimate how many trials would have been required for the latencies to stabilize at asymptotic values.

A number of factors may have accounted for the increases in speed of response across trials. The stimuli themselves may have become more familiar and more easily recognized, but the experimental design permitted no conclusions on this factor because the stimuli were identical across trials. Another factor that may have facilitated responses on later trials could have been that the size of the stimulus set was in effect tremendously reduced after the first trial--from the set of all possible picturable objects to the set of exactly 50 items that the subject by then knew to be involved in the experiment. For subjects in the two experimental conditions, the effective stimulus set for a given item was reduced even further--to a set of just ten stimuli that had been previously presented as having names with a designated WF or AOA level. This further reduction in stimulus set size does not, however, seem to have helped subjects in the experimental conditions, since the increase in speed of naming was not greater in these conditions, over all items, than it was in the control condition.

A third factor in the increase of naming speeds over trials could have been that the accessing of names for the stimuli in the first trial, and again on the second trial, resulted in their being placed in a memory buffer that was more immediately addressable than TLTM. If this was the case, one would expect that the AOA level of a name (as an index of its status in TLTM) would have less influence on naming speed in a later trial than on the first trial. Further, if names were placed in a temporary memory buffer, one might expect some decay of these memories, so that (other things being equal) the longer the period intervening between presentations of the same stimulus, the smaller the increase in naming speed would be on the second presentation.

Several types of analysis were employed in attempts to understand factors in changes in latencies over trials. In one of these, two multiple regression analyses were performed for the data of each individual subject: (1) prediction of the Trial 2 reciprocals of latencies, and (2) prediction of the Trial 3 reciprocals of latencies. Each analysis employed three independent variables: (a) the reciprocal of the latency of an item on the previous trial, (b) the AOA rating of the name (the combined male-female rating), and (c) the number of items intervening between the presentation of an item on the previous trial and its presentation on the trial for which latency was being predicted. This last variable, which is here called "lag," arose because the order in which stimuli were presented was different for each subject and for each trial; thus, the number of items intervening between presentation of a stimulus on one trial and the next could range from zero to 98. Each analysis was based only on the items for which a given subject had valid responses across the three trials (the number of such items ranged from 28 to the maximum possible, 50). In examining the results, attention was focused on the regression coefficients for the three independent variables. The intercept constants for the regression equations were also examined as indices of the net amount of increase in naming speeds over trials.

Since latencies tended to be correlated over trials, even for individual subjects over items, it was expected that the regression coefficients for the reciprocals of latencies from the previous trial would be generally positive and significant. In all cases but one, these regression coefficients were positive, and in most cases they were also significantly different from zero. If individual cases are considered, there were relatively few cases in which the AOA variable and the lag variable made significant contributions to the prediction over and above the contribution of the latency from the previous trial; the lack of significance, however, may have been due to the relatively small n's involved, because there were some striking trends in the data when all cases were considered. These trends were evaluated by testing the significance (from zero) of the mean values of the raw regression coefficients over subjects in a given condition. From Table 9, it is seen that for the prediction of Trial 2 naming speeds, the mean raw regression

Insert Table 9 about here

coefficients for the AOA ratings and the lags were not significantly different from zero in the control condition, but they tended to be significantly negative in both the experimental conditions. For the prediction of Trial 3 naming speeds, they were significantly negative in all conditions. A closer look at these results is in order.

A negative regression coefficient for the AOA rating indicates that the earlier the name for the item was learned, the greater the increase in naming speed from one trial to the next. The general effect of the AOA level of an item, therefore, was that early-learned names increased in speed over trials more than more recently learned names. This was not true for the Trial 2 data in the control condition, however; in fact, the mean value of the AOA regression coefficients was positive, though not significantly so. On Trial 2, the AOA level of the name either ceased to have an effect, or (at least for a few subjects) tended to have an effect such that the more recently learned names were enhanced in naming speed. This could have been due to the placement of such items in an immediate memory buffer such that the AOA level of the items was either not relevant at all, or such that items that had been difficult to retrieve on the first trial (with longer latencies) had greater residual strength than items that were not difficult to retrieve on the first trial. Nevertheless, by Trial 3 any such effects had disappeared for the control subjects, and the AOA status of the item in TLTM now exerted its effect, as it did for subjects in the experimental conditions in both Trials 2 and 3.

A negative regression coefficient for the lag variable means that the greater the number of items intervening between presentations of an item on two successive trials, the smaller is the increase in naming speed. ("Increase" is to be taken in an algebraic sense, since some naming speeds actually decreased over trials.) In the control condition, 13 out of 15 of these regression coefficients were negative on Trial 2, suggesting that for most subjects there was a relative decay in the memory that was aroused by accessing of the item in the first trial; the mean value of these regression coefficients was just short of significance ($t_{(14)} = -2.07$, $p < .10$). The mean values for subjects in both of the experimental conditions were significantly negative on Trial 2, very much so when the data from the two experimental conditions were combined. The results for the prediction of Trial 3 latencies were similar, but in this case the regression coefficients were highly significant (and negative) even for subjects in the control condition.

The intercept constants in the regression equations were uniformly positive and highly significant, indicating a substantial net improvement in naming speed over trials. It is notable that the improvement from Trial 2 to Trial 3 was greater for subjects in the control condition than for subjects in the experimental conditions, possibly because the latter continued to be handicapped by the introduction of AOA or WF information.

It should be noted, incidentally, that the improvement in naming speed was not simply an effect of trial (i.e., practice), but an effect of repeated stimulus presentation. There were no trends observed whereby naming speeds improved over different words in the same trial. In the control condition, where any correlations between order of presentation and AOA rating were purely accidental, the correlations between order of presentation and reciprocal of latency were all nonsignificant, centering around zero.

Two other analyses of the trial-by-trial data employed repeated-measures analyses of variance for certain groups of subjects and for certain sets of words.

The first of these used data from five male subjects from each group, matched as closely as possible on their scores on the Picture Naming Test and the Advanced Vocabulary Test. The dependent variable was the sum of reciprocals of latencies for four items at each of three distinct levels of the AOA ratings; these items were selected as ones for which each subject had valid responses on all three trials. Thus, the analysis was for Condition x Trial x AOA Level, with the last two factors repeated. The results are given in Table 10. Condition was a significant between-subject

Insert Table 10 about here

main effect; the marginal sums were 269.7, 221.6, and 248.5, for the Control, WF-primed, and AOA-primed conditions, respectively, thus paralleling the findings reported previously. Trial and AOA level were also highly significant main effects, the marginal sums for Trials 1 to 3 being 207.7, 251.9, and 280.2, and those for AOA levels being 276.3 (earliest learned), 242.5, and 221.0 (most recently learned). AOA level and Trial were both treated as fixed factors. The only significant ($p < .05$) interaction was the triple interaction between Condition, Trial, and AOA level, whereby the Trial 2 naming speeds were considerably enhanced over expectation for certain combinations of conditions and AOA levels, notably for the most recently learned names for the WF-primed condition and for both the most recently learned names and the earliest-learned names for the AOA-primed condition.

Because these results were thought to be possibly due to the use of data from a limited number of items and subjects, another analysis was conducted, this time using data from 7 subjects per condition and 8 items per AOA level. The subjects were selected from those in the respective groups who had valid responses on at least 39 items over the three trials, and in such a way that the subjects from the 3 conditions were matched as closely as possible on the number of valid responses (they were not, however, well matched on background psychometric test scores). Eight items were selected at each of three AOA levels such that there was a maximum number of valid responses on these items over three trials from the 21 subjects. The dependent variable was the mean reciprocal latency for a given subject for the items on a given trial at a given AOA level; while some data for individual items were missing, each data point used in the analysis was based on the latencies for at least 7 items. The results are shown in Table 11. In this analysis, the main effect for Condition was just short

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Insert Table 11 about here

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of significance at $\alpha = .05$, but the marginal sums reflected the trends reported earlier (88.24, 79.42, and 83.27 for the three conditions, respectively). Trial was again a highly significant main effect, as was also AOA level, but the ranking of the AOA levels was different from what had been found earlier, the marginal sums for the three levels being 90.68 (earliest learned), 79.04, and 81.21 (most recently learned). There was a significant Condition x AOA-level interaction whereby the relation between AOA level and naming speed was monotonic for the AOA-primed condition but strongly nonmonotonic for the other two conditions. In these latter two conditions, naming speeds for the middle AOA level was below the average for the two end levels. There was also a highly significant interaction between Trial and AOA level. The amount of enhancement in Trial 2 (in relation to

Trial 1 and Trial 3 naming speeds) was a monotonic function of AOA level, early-learned items enhanced least and recently-learned items enhanced most. These two significant interactions are plotted in Figure 3; the ordinate is scaled in terms of reciprocals of latency per item. The

Insert Figure 3 about here

triple interaction between Condition, Trial, and AOA level was not significant, however, although some trends were similar to those found in the previous ANOVA.

About the only conclusion that can be drawn from the ANOVA results is that something peculiar seems to manifest itself n the second presentation of an item. Depending upon the extent to which it is a more recently learned item that is difficult to retrieve on the first trial, its naming speed on the second trial improves more than otherwise. This is possibly due to the added strength it acquires as a result of the long time for retrieval on Trial 1. By the third trial, however, this effect disappears, and if anything, it is the early-learned items whose naming speeds improve more on the third trial. These findings are only suggestive, however, since the trends identified may still be a function of the particular sets of items that were used in the analyses. Furthermore, the effect seems to be more pronounced in the WF-primed and AOA-primed conditions (particularly the latter) than in the control condition. The matter deserves further study with larger samples of items, better controlled for AOA levels, recognizability, and other variables than may have been the case in the present experiment. The use of an analogue of the Brown-Peterson paradigm where lags between successive presentations of an item would be better controlled should be revealing.

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Footnote

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Table 1

Words Used in the Picture Naming Task, Classified by Levels of Word-Frequency (WF) and Age of Acquisition (AOA)

Word Frequency Levels

AOA Levels		(Rare) 1	2	3	4	(Frequent) 5	Mean AOA Rating and Interpretation
	1 (Learned Recently)	CALIPERS SEXTANT STETHOSCOPE SURFBOARD TASSEL	ARMADILLO KAYAK	OBSERVATORY	MICROSCOPE	ASTRONAUT	7.34 (4th-5th grade)
	2	HYDRANT XYLOPHONE	ANVIL SILHOUETTE	BANJO BINOCULARS PENGUIN PROPELLER	WINDMILL	TELESCOPE	5.90 (2nd-3rd grade)
	3	ESCALATOR	ACCORDION CANTEEN IGLOO JUGGLER THERMOS	WALRUS	ANCHOR TYPEWRITER	MOSQUITO	5.16 (1st grade)
	4	CLOTHESPIN MOUSETRAP	FAUCET	AMBULANCE VASE	FLASHLIGHT GIRAFFE PUMPKIN	PITCHER THERMOMETER	4.23 (Kindergarten)
	5 (Early Learned)	--	--	BATHTUB MITTEN	BROOM SPOON UMBRELLA	BANANA DOLL DRUM GHOST PIE	2.77 (Nursery School)
	Mean and Range of SFI	36.85 (34.9-38.4)	41.55 (38.6-43.0)	45.75 (43.7-48.4)	50.57 (49.5-52.5)	54.67 (53.5-57.1)	

Table 2

Correlations Among AOA and WF Measures Over the 50 Words Used in the Picture Naming Task as Compared with Those Over the 220 Words in the Carroll and White (1973b) Norms (in Parentheses)

		Variable					
		1	2	3	4	5	6
AOA--Male Ratings	1	1.000 (1.000)	.944 (.962)	.989 (.993)	-.480 (-.674)	-.465 (-.595)	-.572 (-.721)
AOA - Female Ratings	2		1.000 (1.000)	.982 (.988)	-.492 (-.648)	-.486 (-.566)	-.537 (-.684)
AOA - Male & Female Combined	3			1.000 (1.000)	-.494 (-.668)	-.484 (-.587)	-.566 (-.712)
WF - Thorndike-Lorge	4				1.000 (1.000)	.570 (.796)	.724 (.824)
WF - Kučera-Francis	5					1.000 (1.000)	.511 (.758)
WF - American Heritage	6						1.000 (1.000)
Mean		5.079 (4.828)	4.790 (4.611)	4.960 (4.733)	46.416 (50.546)	45.462 (48.906)	45.878 (49.720)
SD		1.602 (1.994)	1.874 (2.102)	1.674 (2.010)	6.148 (7.484)	4.621 (6.891)	6.467 (8.929)

Table 3

Summary of Results of Psychometric Tests and Experimental Picture-Naming Task, by Group, with t-Tests of Certain Contrasts

		Control Condition (N = 15)	WF-Primed Condition (N = 15)	AOA-Primed Condition (N = 15)	Comparison of Experimental Groups t (df = 28)	WF-Primed & AOA-Primed Combined (N = 30)	Comparison of Control with Combined Experimental Groups t (df = 43)
Hidden Figures	X̄	19.73	11.33	12.67	-0.52	12.00	3.52
	SD	5.62	7.46	6.03	n.s.	6.82	$p < .01$
Thing Categories	X̄	28.47	22.73	26.60	-1.35	24.67	1.40
	SD	9.46	6.32	8.62	n.s.	7.80	n.s.
Controlled Association	X̄	57.47	44.60	42.47	0.37	43.53	2.75
	SD	16.34	14.36	16.10	n.s.	15.29	$p < .01$
Gestalt Completion	X̄	18.20	15.93	16.80	-0.61	16.37	1.72
	SD	1.94	4.73	2.48	n.s.	3.80	n.s.
Adv'd Vocab	X̄	29.47	16.80	16.33	0.14	16.57	5.37
	SD	3.46	8.80	8.72	n.s.	8.76	$p < .01$
Picture Naming	X̄	80.60	68.47	74.00	-0.90	71.23	1.79
	SD	15.41	17.62	14.94	n.s.	16.56	n.s.
Mean AOA Level*	X̄	4.88	4.64	4.69	-0.76	4.66	4.10
	SD	.13	.19	.15	n.s.	.17	$p < .01$

*Mean AOA level (combined male-female ratings) of words responded to on Trial 1 of the experimental picture-naming task.

Table 4

Correlation of Mean Reciprocals of Latencies Obtained in 3 Trials Under 3 Conditions, Control (C), Word-Frequency-Primed (WF), and Age-of-Acquisition-Primed (AOA)

N = 50 Words

		Trial 1			Trial 2			Trial 3		
		C	WF	AOA	C	WF	AOA	C	WF	AOA
Trial 1	C	1.000	.866	.858	.703	.731	.787	.814	.769	.735
	WF		1.000	.882	.604	.827	.814	.698	.790	.760
	AOA			1.000	.577	.805	.890	.695	.762	.782
Trial 2	C				1.000	.652	.699	.816	.708	.619
	WF					1.000	.835	.682	.840	.791
	AOA						1.000	.753	.832	.853
Trial 3	C							1.000	.776	.739
	WF								1.000	.843
	AOA									1.000
	$\bar{X}$	1.108	0.891	1.030	1.424	1.160	1.295	1.568	1.272	1.376
	SD	.268	.209	.243	.213	.152	.177	.205	.173	.182

Note: These correlations are based on mean reciprocals of latencies only for words for which a given subject had valid responses for all three trials.

Table 5

Correlations of Age of Acquisition and Word Frequency Measures with Mean Reciprocal Latencies Over Subjects, by Trial and Condition (N = 50 words), with Multiple Correlation Results for Two of the Variables

(C = Control; WF = Word-Frequency Primed; AOA = Age-of-Acquisition Primed)

		Trial 1			Trial 2			Trial 3		
Condition:		C	WF	AOA	C	WF	AOA	C	WF	AOA
Age of Acquisition Rating by Males	1	-.615	-.584	-.677	-.342	-.531	-.616	-.540	-.526	-.686
Age of Acquisition Rating by Females	2	-.533	-.514	-.639	-.254	-.453	-.572	-.462	-.420	-.600
Age of Acquisition Ratings - Combined	3	-.588	-.560	-.668	-.307	-.501	-.604	-.513	-.436	-.655
Word-Frequency - Thorndike-Lorge SFI	4	.427	.445	.491	.170	.398	.392	.369	.377	.443
Word-Frequency - Kučera-Francis SFI	5	.372	.321	.510	.149	.285	.433	.296	.300	.341
Word-Frequency - American Heritage SFI	6	.499	.470	.480	.127	.378	.393	.356	.396	.482
$r_{34} = -.494$	β_3	-.499	-.450	-.563	-.302	-.402	-.543	-.438	-.396	-.577
	β_4	.180	.223	.213	.021	.200	.124	.152	.181	.159
	$R_{c \cdot 34}$	.608	.593	.693	.313	.530	.614	.530	.510	.669

Table 6

Results Based on Individual Subject Data Comparing Age-of-Acquisition Ratings and Thorndike-Lorge Word Frequency SFI as Predictors of Reciprocals of Naming Latencies, by Condition and Trial

Symbols: r_A = Correlation between reciprocal of latency and combined male-female ratings of age of acquisition, over words with valid responses in all three trials

r_F = Correlation between reciprocal of latency and Thorndike-Lorge SFI, over words with valid responses in all three trials.

	Trial 1			Trial 2			Trial 3		
Condition	C	WF	AOA	C	WF	AOA	C	WF	AOA
Number of subjects (out of 15) for whom $(-r_A) > (r_F)$	13	12	13	7	11	11	12	10	13
Distribution of p values for r_A:									
$p < .01$	11	9	13	1	5	7	5	6	10
$.01 < p < .05$	2	3	2	2	5	4	2	2	3
$p > .05$	2	3	0	12	5	4	8	7	2
Highest value of $-r_A$	.555	.651	.642	.437	.632	.629	.424	.633	.550
Median value of $-r_A$	.403	.361	.439	.143	.277	.345	.260	.308	.391
Lowest value of $-r_A$	.248	.092	.318	-.012	-.018	.196	.073	-.150	.243
Number of subjects (out of 15) for whom the word frequency variable makes a significant ($p < .05$) added contribution to prediction of latency	1	1	4	0	1	2	1	0	1

Table 7

Prediction of Mean Reciprocal Latencies (Over Words) from Individual Difference Measures, by Trial, for Subjects Pooled over Conditions (All Variables Standardized Within Groups)

N = 45

Intercorrelations

Test or Measure		1	2	3	4	5	6	7
Hidden Figures	1	1.000	.258	.269	.526	.251	.219	.335
Thing Categories	2		1.000	.679	.196	.343	.275	.226
Controlled Association	3			1.000	.279	.349	.195	.221
Gestalt Completion	4				1.000	.097	.204	.127
Advanced Vocabulary	5					1.000	.188	.301
Picture Naming Test	6						1.000	.220
No. of Valid Words[1]	7							1.000

Multiple Regression Analyses

		Trial 1			Trial 2			Trial 3		
		r_c	β	t	r_c	β	t	r_c	β	t
Hidden Figures	1	.167	-.092	- .67	.196	-.124	- .90	.201	-.071	- .50
Thing Categories	2	.349	.136	.89	.339	.190	1.24	.252	-.006	- .04
Controlled Association	3	.278	.065	.43	.245	-.018	- .12	.252	.090	.56
Gestalt Completion	4	.188	.048	.37	.354	.266	2.01	.342	.231	1.69
Advanced Vocabulary	5	.130	-.101	- .83	.062	-.141	-1.15	.164	.027	.21
Picture Naming Test	6	.688	.621	5.36**	.658	.579	4.96**	.666	.624	5.14**
No. of Valid Words[1]	7	.336	.209	1.74	.250	.134	1.11	.122	-.048	- .38
R		.737			.732			.707		
$F_{(7,37)}$		6.30			6.10			5.29		
p		<.001			<.001			<.001		

[1]This is the number of words for which the subject had valid responses on all three trials of the experimental picture-naming task.

**p < .01

Table 8

Covariance Analyses of Trial 1 Latencies

I. Dependent Variable: Mean reciprocal latencies, Trial 1, for subjects over words responded to.
Covariate: Picture Naming Test and the Mean AOA (combined male-female) Rating of words responded to.

Condition	Unadjusted Means	Adjusted Means	
Control	1.130	1.097	Contrast (Control vs. WF-Primed and AOA-Primed), $p < .025$
WF-Primed	.924	.956	Contrast (WF-Primed vs. AOA-Primed), $p < .012$
AOA-Primed	1.057	1.057	

p of overall regression $< .001$

II. Dependent Variables: Reciprocals of latencies, Trial 1, for individual words (a separate analysis for each of 50 words)
Covariate: Picture Naming Test

Contrast 1: Comparison of WF-Primed and AOA-Primed Conditions

	No. of words	Words
Adjusted Mean for AOA-Primed Group Greater	46	
—of these: Significant only at $\alpha = .05$	3	ANCHOR, PIE, SPOON
—of these: Significant at $\alpha = .01$	3	CLOTHESPIN, DRUM, PITCHER

Contrast 2: Comparison of Control Condition with Combined Experimental Conditions

	No. of words	Words
Adjusted Mean for Control Condition Greater.	32	
—of these: Significant only at $\alpha = .05$	9	ANCHOR, BATHTUB, DRUM, KAYAK, MICROSCOPE, MOUSETRAP, PENGUIN, SURFBOARD, UMBRELLA
—of these: Significant at $\alpha = .01$	3	BANANA, CANTEEN, IGLOO

Table 9

Regression Analysis for Prediction of Trial 2 and Trial 3 Reciprocals of Latencies

			Trial 2				Trial 3			
Condition:			C	WF	AOA	C-(WF + AOA)	C	WF	AOA	C-(WF + AOA)
Reciprocal of latency on previous trial	b_1	$\bar{X}$	.4643	.4928	.5304		.3740	.5186	.4567	
		s	.1484	.2085	.1423		.1990	.2623	.1337	
		$t(H_o)$	12.09**	9.15**	14.44**	-0.91	7.28**	7.66**	13.32**	-2.07
AOA rating of name	b_2	$\bar{X}$	.0043	- .0190	- .0015		- .0468	- .0238	- .0320	
		s	.0243	.0252	.0023		.0424	.0344	.0256	
		$t(H_o)$	0.69	- 2.92*	- 2.00	2.59**	-4.27**	- 2.68*	- 4.84**	-1.73
Lag between successive presentations of an item	b_3	$\bar{X}$	- .0016	- .0012	- .0024		- .0030	- .0022	- .0016	
		s	.0031	.0017	.0024		.0032	.0021	.0031	
		$t(H_o)$	- 2.07	- 2.73*	- 3.87**	0	-3.67**	- 3.96**	- 2.06	-1.31
Intercept	a	$\bar{X}$	.9784	.8702	.9336		1.4239	.8695	1.0189	
		s	.3519	.2778	.2435		.5551	.2982	.3006	
		$t(H_o)$	10.77**	12.13**	14.85**	.83	9.93**	11.29**	13.13**	3.76**

*p < .05; **p < .01.

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Table 10

Analysis of Variance Results for Reciprocals of Latencies Over 4

Items per AOA Level; 5 Subjects per Condition

	SS	df	MS	F, p
Between Subjects	58.77	14	4.20	
Condition	25.74	2	12.87	4.68, $p < .05$
Subjects within group	33.03	12	2.75	
Within Subjects	134.69	120	1.12	
Trial	59.25	2	29.63	55.91, $p < .001$
Condition x Trial	2.60	4	0.65	1.23, n.s.
Trial x Subjects within group	12.62	24	0.53	
AOA Level	34.36	2	17.18	31.82, $p < .001$
Condition x AOA Level	0.84	4	0.21	.39, n.s.
AOA Level x Subjects within group	12.93	24	0.54	
Trial x AOA Level	0.51	4	0.13	.72, n.s.
Condition x Trial x AOA Level	3.19	8	0.40	2.22, $p < .05$
Trial x AOA Level x Subjects within group	8.39	48	0.18	

Table 11

Analysis of Variance Results for Mean Reciprocals of Latencies Over 8 (or 7) Items per AOA Level; 7 Subjects per Condition

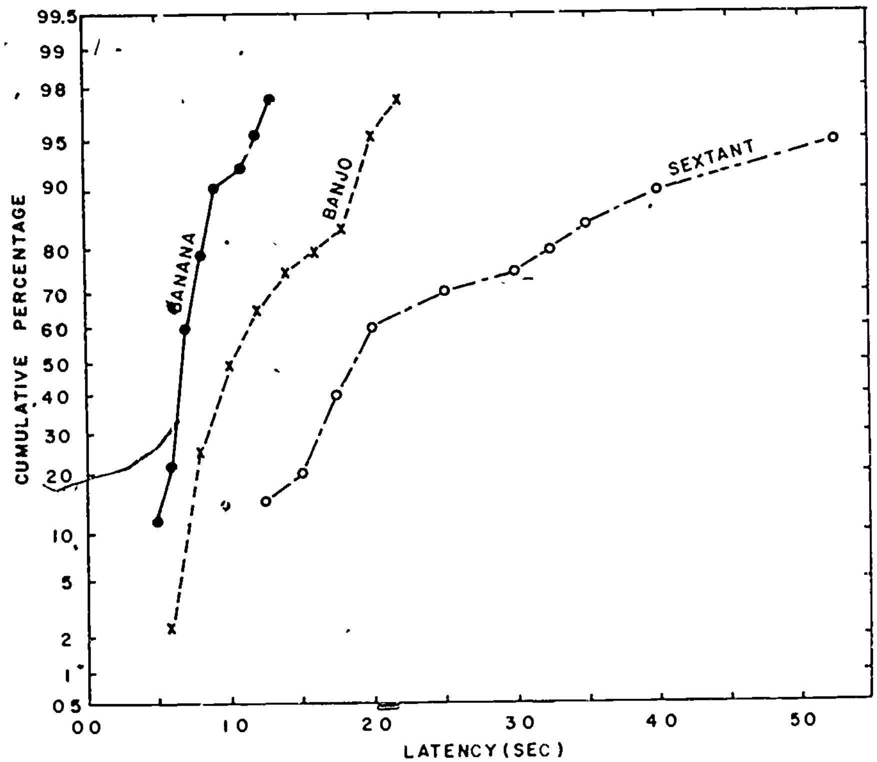
	SS	df	MS	F, p
Between Subjects	3.5077	20	.1754	
Condition	0.6208	2	.3104	1.93, $p > .10$
Subjects within group	2.8869	18	.1604	
Within Subjects	6.7183	168	.0400	
Trial	3.7268	2	1.8634	139.06, $p < .001$
Condition x Trial	.1082	4	.0271	2.02, $p > .10$
Trial x Subjects within group	.4812	36	.0134	
AOA Level	1.2163	2	.6082	61.43, $p < .001$
Condition x AOA Level	.1846	4	.0462	4.67, $p < .01$
AOA Level x Subjects within group	.3558	36	.0099	
Trial x AOA Level	.1200	4	.0300	4.41, $p < .001$
Condition x Trial x AOA Level	.0377	8	.0047	0.69, n.s.
Trial x AOA Level x Subjects within group	.4877	72	.0068	

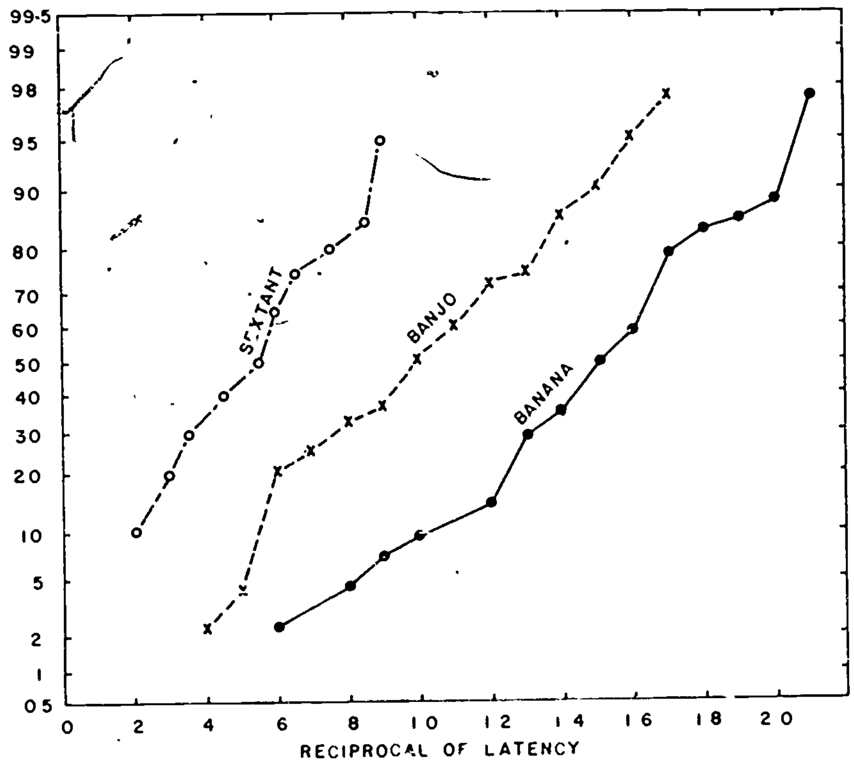
Figure Captions

Figure 1. Cumulative percentage distributions (over subjects) of latency measurements for three words, Trial 1 data. At left, the cumulative percentages are plotted against raw latencies in seconds. At right, they are plotted against reciprocals of these latencies.

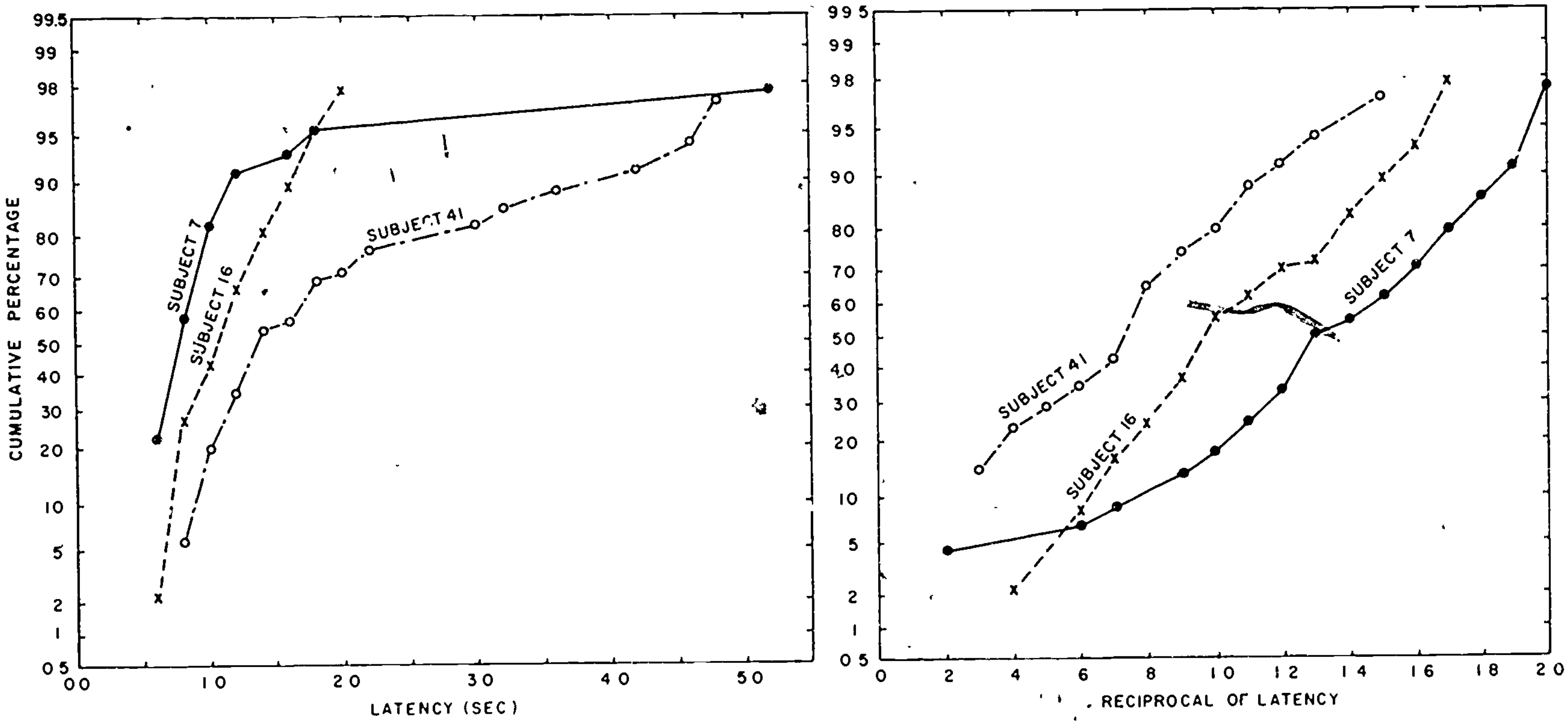
Figure 2. Cumulative percentage distributions (over words) of latency measurements obtained from three subjects, a fast responder (#7), an average responder (#16), and a slow responder (#41), on Trial 1. At left, the cumulative percentages are plotted against raw latencies in seconds. At right, they are plotted against reciprocals of these latencies.

Figure 3. Significant interactions from analysis of variance of selected data.

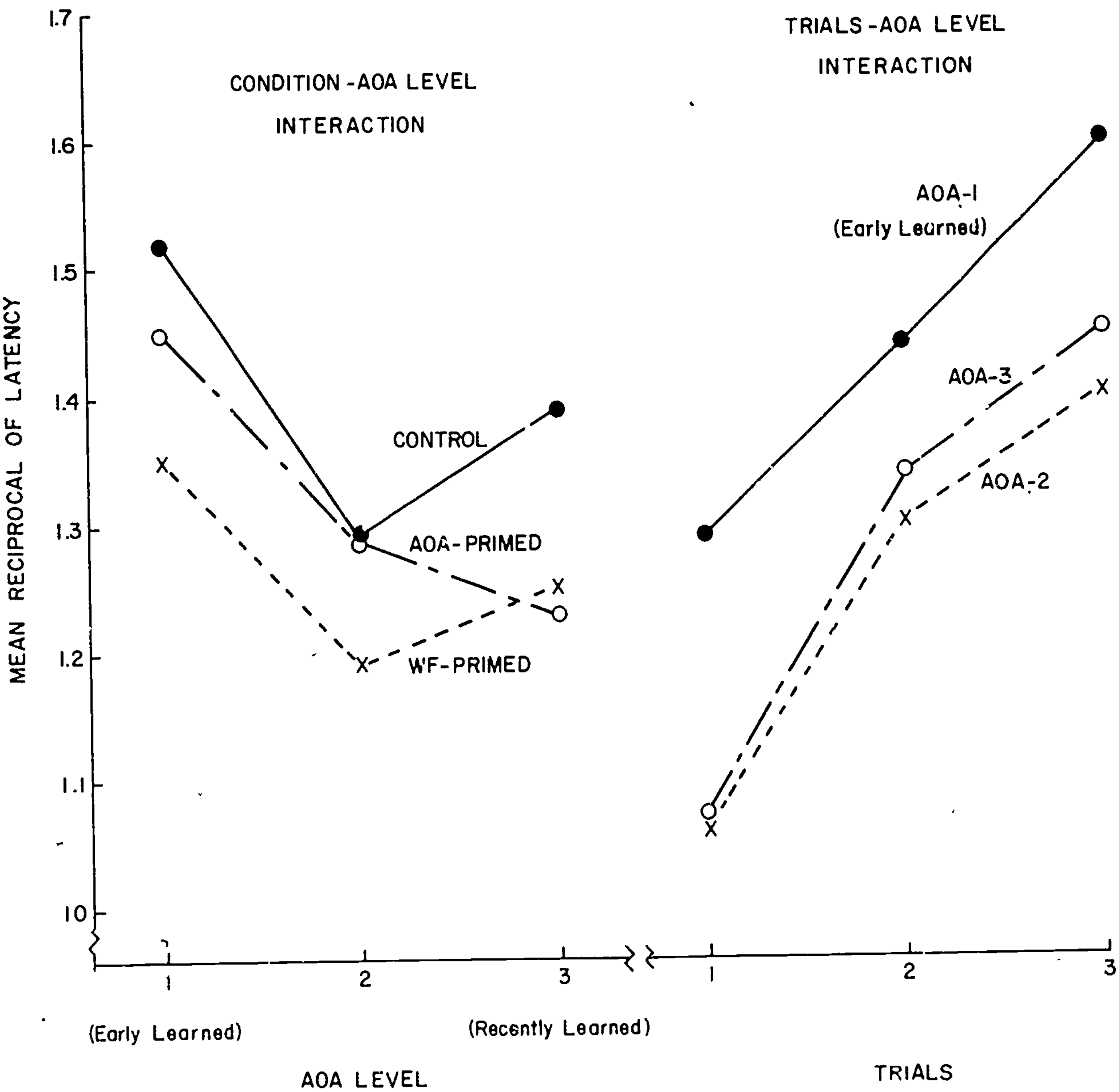

CUMULATIVE PERCENTAGE
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
BANANA
BANJO
SEXTANT
0.0
1.0
2.0
3.0
4.0
5.0
LATENCY (SEC)


99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
SEXTANT
BANJO
BANANA
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
RECIPROCAL OF LATENCY

-46-


CUMULATIVE PERCENTAGE
SUBJECT 7
SUBJECT 16
SUBJECT 41
LATENCY (SEC)
RECIPROCAL OF LATENCY
SUBJECT 41
SUBJECT 16
SUBJECT 7

-47-



CONDITION-AOA LEVEL INTERACTION
TRIALS-AOA LEVEL INTERACTION
MEAN RECIPROCAL OF LATENCY
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
CONTROL
AOA-PRIMED
WF-PRIMED
AOA-1 (Early Learned)
AOA-3
AOA-2
1
2
3
(Early Learned)
(Recently Learned)
AOA LEVEL
TRIALS