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ABSTRACT

Four experiments were conducted to assess the effects of certain stimulus variables on children's discrimination learning. In general, it was found that word frequency was negatively related to discrimination learning as long as the words were meaningful to the subjects. Moreover, the relationship between word and performance reversed in free-recall learning, as was expected. Equivalent relationships between frequency and learning were obtained with verbal and pictorial materials. The implications of these results were discussed in the context of popular accounts of memorial representation. (Author)

A CLARIFICATION OF FREQUENCY EFFECTS IN CHILDREN'S DISCRIMINATION LEARNING

WISCONSIN RESEARCH AND DEVELOPMENT

CENTER FOR
COGNITIVE LEARNING

Technical Report No. 294

A CLARIFICATION OF FREQUENCY EFFECTS IN CHILDREN'S DISCRIMINATION LEARNING

by

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Report from the Project on
Children's Learning and Development

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Statement of Focus

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints—financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher student achievement and self-direction in learning and in conduct and also to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

Acknowledgments

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Abstract

Four experiments were conducted to assess the effects of certain stimulus variables on children's discrimination learning. In general, it was found that word frequency was negatively related to discrimination learning as long as the words were meaningful to Ss. Moreover, the relationship between word frequency and performance reversed in free-recall learning, as was expected. Equivalent relationships between frequency and learning were obtained with verbal and pictorial materials. The implications of these results were discussed in the context of popular accounts of memorial representation.

I
Introduction

The purpose of the present series of experiments was to determine the effects of certain stimulus variables on children's discrimination learning. The three dimensions on which materials were varied were "background frequency" (as inferred from norms such as those of Thorndike and Lorge, 1944), meaningfulness (as defined by Ss' semantic responses to items), and modality (verbal versus pictorial representations.

According to the tenets of frequency theory (Ekstrand, Wallace, & Underwood, 1966): (i) discrimination learning is assumed to involve subjective frequency discriminations between "correct" and "incorrect" pair members. It has further been assumed that: (ii) the accrual of subjective frequency to items in a pair may be influenced by the background or preexperimental frequency of the items, in a manner akin to Weber's Law. Under the second assumption, discrimination of situational frequency differences should be easier for items low in background frequency than for those high in background frequency.

In earlier studies (Ghatala & Levin, 1973; Ghatala & Levin, 1974; Ghatala, Levin, & Wilder, 1973; Levin, Ghatala, & DeRose, in press), we have invoked the background-frequency assumption to account for various phenomena in children's discrimination learning. The emphasis in the present research is on clarifying the role of background frequency as it operates in conjunction with other stimulus variables previously demonstrated (or presumed) to have an effect on discrimination learning.

II
Experiment I

One of the assumptions just mentioned was that discrimination learning should be better with materials of low background frequency than with those of high background frequency. However, tests of this prediction utilizing high and low-frequency words have been equivocal. While some studies have found that low-frequency word pairs are learned significantly better than high-frequency pairs (e.g., Rowe & Paivio, 1971b, Experiments I and IV; Underwood, Broder, & Zimmerman, 1973), others have not (e.g., Ingison & Ekstrand, 1970; Paivio & Rowe, 1970; Rowe & Paivio, 1971b, Experiments II and III). And as Paivio (1971) has argued, even when such word-frequency effects are found they are generally not as potent as those produced by other stimulus variables--in particular, stimulus concreteness as defined by Paivio, Yuille, and Madigan's (1968) norms.

Recently Ghatala and Levin (1974) presented evidence to suggest that the elusive effect of word frequency in discrimination learning might be due to the operation of another factor which may be regarded as "meaningfulness" (though not in the usual verbal-learning sense--cf. Underwood & Schulz, 1960). In a frequency judgment task, it was found that subjective frequency differences between high-frequency words and low-frequency words for which Ss knew the meanings were in accordance with predictions stemming from Weber's Law. In contrast, the lack of difference between high-frequency words and low-frequency words for which Ss did not know the meanings was not in accordance with Weber's Law. This was true even though the "meaningful" and "nonmeaningful" low-frequency words were fairly comparable in terms of their average normative (Thorndike & Lorge, 1944) frequencies, these being 8.2 and 6.0 occurrences per million respectively.

The Ghatala and Levin results indicated that within the context of a frequency judgment task, Weber's Law holds for materials which are meaningful to Ss but not for materials which are not meaningful. This finding in turn suggests that meaningfulness (as defined here) may well be a crucial variable to control when investigating the effects of background frequency in discrimination learning. The purpose of Experiment I was to follow up on this suggestion. Predictions based on the Ghatala and Levin results were: (a) discrimination lists consisting of low-frequency words which are meaningful to Ss will be better learned than lists consisting of high-frequency words; but (b) lists consisting of low-frequency words which are not meaningful to Ss will be at least as difficult as high-frequency word lists.

Method

Subjects

The Ss were 80 sixth-grade children attending an elementary school located in a middle-class neighborhood in Ogden, Utah. The Ss were randomly assigned in equal numbers to the four conditions of the experiment.

Design and Materials

Four types of verbal-discrimination lists comprised the conditions of the experiment. One list (Hi-F) consisted of high-frequency words from the AA and A range of the Thorndike and Lorge (1944) norms. A second list (Lo-F/Hi-M) consisted of low-frequency words (less than 25 occurrences per million) whose meanings were known by Ss in this age group (e.g., "hatchet," with a normative frequency of 8), and a third list (Lo-F/Lo-M) consisted of low-frequency words (also less than 25 occurrences per million) whose meanings were unknown by these Ss (e.g., "dory," with a normative frequency of 7).

The meaningfulness of the low-frequency words was determined in a previous experiment (Ghatala & Levin, 1974) by having sixth-grade children pronounce and then define the words. (Any definition was taken to indicate that the word had meaning for the S.) The Lo-F/Hi-M words were those which at least 80% of the Ss could both pronounce and define. The Lo-F/Lo-M words were those which at least 80% of the Ss could pronounce, but no more than 20% could define. The mean Thorndike-Lorge frequency of the words selected for the Lo-F/Hi-M list was 5.93, and that for the Lo-F/Lo-M words was 5.80.

A fourth list consisted of nonsense items which were obtained by transforming the Lo-F/Lo-M words according to the following rule: Replace each consonant with the next consonant in the alphabet, but retain the same vowels. The nonsense condition was included to sample the lower extremes of the meaningfulness dimension. That is, while the Lo-F/Lo-M words have little semantic content for Ss of this age, their possible closer resemblance to known English words (in terms of orthographic structure and pronunciability) might afford more meaning and/or associations for Ss than would nonsense words. The frequency judgment results for nonsense words appeared to support this speculation (cf. Ghatala & Levin, 1974), and led to the present prediction of inferior discrimination learning with nonsense words in comparison to Hi-F materials.

All lists consisted of 15 pairs. Two versions of each list contained different random pairings of items. For each version of each list, one member of each pair was selected as correct; in a second list the other members of the pairs were correct. Of the 20 Ss in each condition, five were assigned to each list variation. All lists were constructed such that: (a) the 15 pairs occurred in three random serial orders; (b) within any order, the correct members of the pairs occurred approximately equally often in the right and left positions; and (c) across orders, the correct member of a pair occurred no more than twice in the same position. The items in the pairs were typed side by side on 5 by 8 inch plain white cards and placed in notebooks. The correct members of the pairs were starred.

Procedure

The Ss were run individually in a private room in the school building. Each S received one silent (no-guess) anticipation trial followed by four anticipation response trials. The pairs were presented at a three-second rate timed by means of an electronic metronome and Ss indicated their choices by pointing.

Results and Discussion

Mean discrimination learning performance over four trials was 51.10, 46.80, 46.70, and 41.00 in the Hi-F, Lo-F/Hi-M, Lo-F/Lo-M, and Nonsense conditions respectively. In keeping with the Ghatala and Levin (1974) analyses, Dunnett comparisons (utilizing the Hi-F condition as the "control group") were conducted to assess the predicted effects. According to this procedure, it was found that although the Nonsense condition was significantly inferior to Hi-F, neither of the Lo-F conditions differed significantly from Hi-F ($\alpha = .05$). Thus, while the prediction of inferior performance in the Nonsense condition was confirmed, the prediction of superior performance in the Lo-F/Hi-M condition was not.

The lack of difference between the Lo-F/Hi-M and Hi-F conditions was puzzling in light of differences obtained with these same materials in a frequency judgment task (Ghatala & Levin, 1974). However, an inspection of the sample variances revealed that the variance for the Lo-F/Hi-M group was twice that of Hi-F and three times that of Lo-F/Lo-M, suggesting the operation of factors peculiar to Lo-F/Hi-M Ss. In an attempt to ascertain the reason for the large variation among individuals in the Lo-F/Hi-M condition, the Ss in this group were administered the definitions test originally used by Ghatala and Levin.

On the definitions test, the Ss were presented each of the 30 Lo-F/Hi-M words and required to pronounce and then define each one. The results obtained from this procedure clearly indicated that while the items had uniformly high meaningfulness (using the criteria previously described), individual Ss exhibited considerable variation in their ability to pronounce and define the words. Of particular interest in this regard was the significant ($p < .01$) correlation, $r = .68$, between number of words correctly recognized (pronounced and defined) and total correct on the discrimination task: a trend which provides evidence in support of the original hypothesis, in that as Ss' semantic knowledge of the words increased so did their discrimination learning scores.

There were two stages to the definitions test--S first had to pronounce each word and then define it. In cases where S failed to pronounce the word reasonably, E pronounced it for S to define. Accordingly, three types of errors were possible: (i) S could fail to pronounce the words correctly yet give an acceptable definition once E pronounced it; (ii) S could pronounce the word correctly yet not be able to give an adequate definition; or (iii) S could neither pronounce nor define the word. The majority of the errors (58%) fell into the first category, with 34% and 8% falling into the second and third categories respectively. Following the frequency-meaningfulness hypothesis, this result suggests that pronouncing the words for Ss during discrimination learning should improve the performance of the Lo-F/Hi-M group since many words which are "meaningless" when unpronounced would become "meaningful" when pronounced by E. On the other hand, pronouncing the words for Ss in the Hi-F and Lo-F/Lo-M groups should have little effect. In the former case, Hi-F words are highly familiar and are probably pronounced covertly by Ss, and in the latter, it is doubtful that simple pronunciation would increase the meaningfulness of Lo-F/Lo-M words.

Another change in procedure was suggested by consideration of the latencies of the responses on the definitions test. The Ss were allowed up to five seconds to pronounce a word and then a further 20 seconds to define it. Many Ss, even those who correctly defined all the words, displayed fairly long latencies (especially in the pronouncing stage, but also in the definition stage). The three-second presentation rate utilized in the verbal-discrimination task was obviously too short for many Ss in the Lo-F/Hi-M condition to pronounce (covertly) and get a meaning response for both words in a pair.

In this regard, the results of Ghatala and Levin (1974) which led to the present predictions for verbal-discrimination learning were obtained in an absolute frequency judgment task in which items were presented one at a time for five seconds, with Ss explicitly instructed to pronounce each item to themselves as it appeared. The present predictions might therefore be confirmed under conditions more closely resembling those in which the effects of frequency and meaningfulness were first demonstrated.

III
Experiment II

The purpose of Experiment II was to compare the three word groups from Experiment I using a slower rate of presentation and with E's pronunciation of the words. (Since significantly poorer performance in the Nonsense condition was already demonstrated under the procedures of Experiment I, and since this condition is not crucial to the present hypothesis, it was excluded here.)

Method

Subjects

The Ss were forty-eight sixth-grade children from an Ogden, Utah, elementary school demographically similar to the one in Experiment I. The Ss were randomly assigned in equal numbers to the three conditions of the experiment (Hi-F, Lo-F/Hi-M, and Lo-F/Lo-M).

Materials

The lists for the three conditions were the same as in Experiment I.

Procedure

The procedure was the same as in Experiment I with two exceptions: The E pronounced both words in a pair during the anticipation phase on all trials, and the rate of presentation was slowed to five seconds.

Results and Discussion

Performance on the discrimination learning task is summarized in the last row of Table I. While the three means are in the predicted order, Dunnett tests ($\alpha = .05$) revealed that relative to Hi-F, Lo-F/Lo-M was significantly inferior but Lo-F/Hi-M was not significantly superior.

TABLE I

MEAN NUMBER OF CORRECT RESPONSES OVER FOUR TEST TRIALS BY EXPERIMENTAL CONDITION AND PERFORMANCE ON THE DEFINITIONS TEST (EXPERIMENT II).

	Hi-F	Lo-F/Hi-M	Lo-F/Lo-M
High Definitions	47.75	53.22	40.33
	(N=8)	(N=9)	(N=6)
Low Definitions	47.12	45.00	41.90
	(N=8)	(N=7)	(N=10)
Weighted Mean	47.44	49.62	41.31

Once again, in order to analyze this result more fully, the definitions test was administered to Ss in the Lo-F/Hi-M condition. As in Experiment I, it was anticipated that Ss who would do well on the definitions test were those who also did well on the discrimination learning task. However, it is possible that this could be due simply to the fact that, in general, "brighter" Ss (i.e., Ss who know more low-frequency word definitions) are also better learners. In order to choose between a general hypothesis (that brighter children learn faster) and a specific hypothesis (that children who know the meanings of low-frequency items learn those particular items faster), Ss in the Hi-F and Lo-F/Lo-M conditions were also administered the Lo-F/Hi-M definitions test. To be consistent with the procedure followed in the discrimination task, E pronounced all of the words and, after hearing each word, S was required to define it.

The results are presented in the body of Table 1. The 48 Ss were divided into two approximately equal-sized groups based on their definitions test performance. It may be seen that only in the Lo-F/Hi-M condition is there a substantial effect of knowing the definitions on discrimination performance. Looked at another way, for those Ss who knew most of the definitions (High: 27 or more correct out of 30), a nested comparison revealed that Lo-F/Hi-M Ss were superior to Hi-F Ss ($t = 2.03$, $df = 42$, $p < .05$); but for those who knew fewer definitions (Low: between 17 and 26 correct out of 30), no significant difference was observed ($|t| < 1$).

Thus, consideration of only the overall discrimination performance did not yield significant differences between Ss in the Lo-F/Hi-M and Hi-F conditions, contrary to predictions. Despite the procedural changes from Experiment I to Experiment II (E-pronunciation of the items and a slower presentation rate), there was still appreciable variation among Ss in their knowledge of the meanings of the Lo-F/Hi-M words. However, the analysis of discrimination learning scores for the Hi-F and Lo-F/Hi-M Ss as a function of their scores on the definition test clearly supported the hypothesis that low-frequency words are better discriminated than high-frequency words as long as Ss know the meanings of the low-frequency words.

Taken together, the results of Experiments I and II provide some support for the notion that background frequency influences the difficulty of discrimination learning, but that the meaningfulness of the stimuli is a variable moderating the effects of frequency. The data of the first two experiments were less than satisfying, however, because complete control over meaningfulness was not obtained with the materials used. Consequently, in the remaining experiments new high- and low-frequency materials were selected so that better control over meaningfulness could be obtained.

IV
Experiments III and IV

In Experiment III, discrimination learning with revised Hi-F and Lo-F/Hi-M verbal materials was compared. As in the previous experiments, it was expected that the Lo-F/Hi-M materials would produce superior learning. However, in order to demonstrate that this finding could not be attributable simply to the particular idiosyncracies of the materials selected, in Experiment IV the same materials were compared under free-recall learning conditions. Based on the well-known differential effects of word frequency on recognition- and recall-type measures of learning (cf. Kintsch, 1970), it was expected that the present Lo-F/Hi-M materials, while superior to Hi-F materials in discrimination learning would be inferior in free recall.

In addition, experimental line-drawings corresponding to the verbal stimuli were included to see if these would be similarly responsive to background-frequency manipulations. Although unforeseen at the time, the inclusion of pictorial materials provides data relevant to current theorizing about picture-word differences in learning (cf. Paivio, 1971). Such issues will be discussed following a presentation of the experimental results.

Method

Materials

Fifty-two concrete nouns were selected, with half designated as Hi-F and half as Lo-F as determined from Carroll, Davies, and Richman's (1971) word-frequency norms (third-grade level). By selecting from actual materials used by children, we sought to obtain more realistically-based high- and low-frequency words than those determined from more remote norms such as those of Thorndike and Lorge (1944). In particular, the Carroll et al. norms are derived from samples of children's reading materials, grade level by grade level. Overall, the Lo-F words (mean of 7.5 occurrences in third-grade materials, range of 1 to 19) appeared in such samples much less frequently than the Hi-F words (mean of 351.5, range of 232 to 785). An attempt was made to match Hi-F and Lo-F words with respect to their general object class (e.g., "dog" with "ape"; "window" with "chimney") as much as was possible. Line-drawings of each of these items were also created.

The final selection of words and pictures resulted from initial pilot testings with a larger sample of materials. In these pilotings, there were two major concerns: (a) that the Hi-F and Lo-F items generated from the Carroll et al. (1971) norms corresponded to our Ss' phenomenal experience with such items; and (b) that Ss possessed the desired labels for each of the pictures (thereby also indicating that all materials were "meaningful" to Ss). To deal with the first concern, we presented mixed-frequency word pairs aurally to beginning fourth graders, with Ss instructed to circle the letter on supplied answer sheets which corresponded to the word in each pair that they had "heard, seen, or used more often." To deal with the second concern, we showed the pictures one at a time to additional Ss, and asked them to label each one. Following these procedures, it was possible to select 26 Hi-F and 26 Lo-F items which met at least an 80% agreement criterion on both the phenomenal-frequency judgment and the picture labeling tasks. From these items, 13 Hi-F pairs were randomly formed for the discrimination learning task (Experiment III), with one item in each pair designated correct. The matched (from the pilot studies) Lo-F items were then selected to form comparable pairs. A random sample of 18 of the Hi-F items and their Lo-F counterparts were selected for the free-recall task (Experiment IV). Both verbal and pictorial items appeared on cards inserted into looseleaf binders.

Subjects and Design

A total of 123 fourth graders (different from those used in the pilot studies) from an elementary school in the Midwest participated in the two experiments. Of these, 75 Ss participated in Experiment III, and 48 in Experiment IV. Within each experiment, Ss were randomly assigned in approximately equal numbers to the four cells of the design as defined by the combination of Frequency (Hi-F vs. Lo-F) and Modes (Words vs. Pictures).

Procedure

In the discrimination task, Ss were shown each pair for three seconds under the anticipation method (with one silent study trial). Additionally, E pronounced the two pair members during the anticipation phase in the Word conditions only (to guarantee that each word would be recognized). Following the initial study trial, two response trials were provided.

In the free-recall task, stimuli were presented one at a time for three seconds apiece. As in the discrimination task, E named aloud each stimulus in the Word conditions during presentation. Four alternating presentation trials and S-paced recall trials were provided.

Results and Discussion

Mean performance on the two tasks is presented in Figure 1. On the free-recall task, S-produced labels that were synonymous to the intended ones were scored as correct in the Picture conditions.

Since there were slightly unequal numbers of Ss in the four discrimination learning conditions, the harmonic mean was computed ($\tilde{n} = 18.72$) and unweighted means analysis of variance applied to the two factors. According to this procedure, pictures were discriminated better than words ($F = 20.26$, $df = 1/71$, $p < .001$), a result in accord with previous data for both children (e.g., Wilder & Levin, 1973) and adults (e.g., Rowe & Paivio, 1971a). Moreover, as anticipated with meaningful materials, Lo-F was found to be superior to Hi-F ($F = 7.36$, $df = 1/71$, $p < .01$). The Frequency by Modes interaction was not significant ($F < 1$).

The picture-over-word effect remained on the free-recall task ($F = 10.76$, $df = 1/44$, $p < .01$), which is consistent with previous results (e.g., Cole, Frankel, & Sharp, 1971; Paivio & Csapo, 1969). However, as was expected, the frequency effect reversed: that is, Hi-F stimuli were better recalled than Lo-F stimuli ($F = 15.68$, $df = 1/44$, $p < .001$). Once again, the interaction was non-significant ($F = 1.93$, $df = 1/44$, $p > .10$).

Thus, the major premise of the present research (viz., that background frequency is negatively related to discrimination learning performance) was supported. Conversely, a positive relationship between background frequency and free-recall performance was observed, suggesting that different cognitive processes were evoked by the two tasks even though they included the same materials.

Since no interaction between frequency and stimulus mode was obtained in either task, it might be concluded that background frequency influences the learning of pictorial as well as verbal materials. While this seems obvious in the case of free recall (where S must store and retrieve the stimuli's labels which are identical for both types of material), it is less so in the case of discrimination learning (where production of the stimuli's verbal labels is not required).[1] Consequently, additional data to those of Experiment III were collected to corroborate the existence of the effect with pictures. Seventeen fourth graders from the same school used in Experiment III were given a much longer (26-pair) list, formed by including both the previous Hi-F and Lo-F picture pairs in a single mixed list. The obtained difference of 1.65 correct responses in favor of Lo-F was statistically significant

[1] However, recent evidence (cf. Tversky, 1973) suggests that verbal processes are involved in ostensibly non-verbal tasks (such as the pictorial discrimination task of the present study).

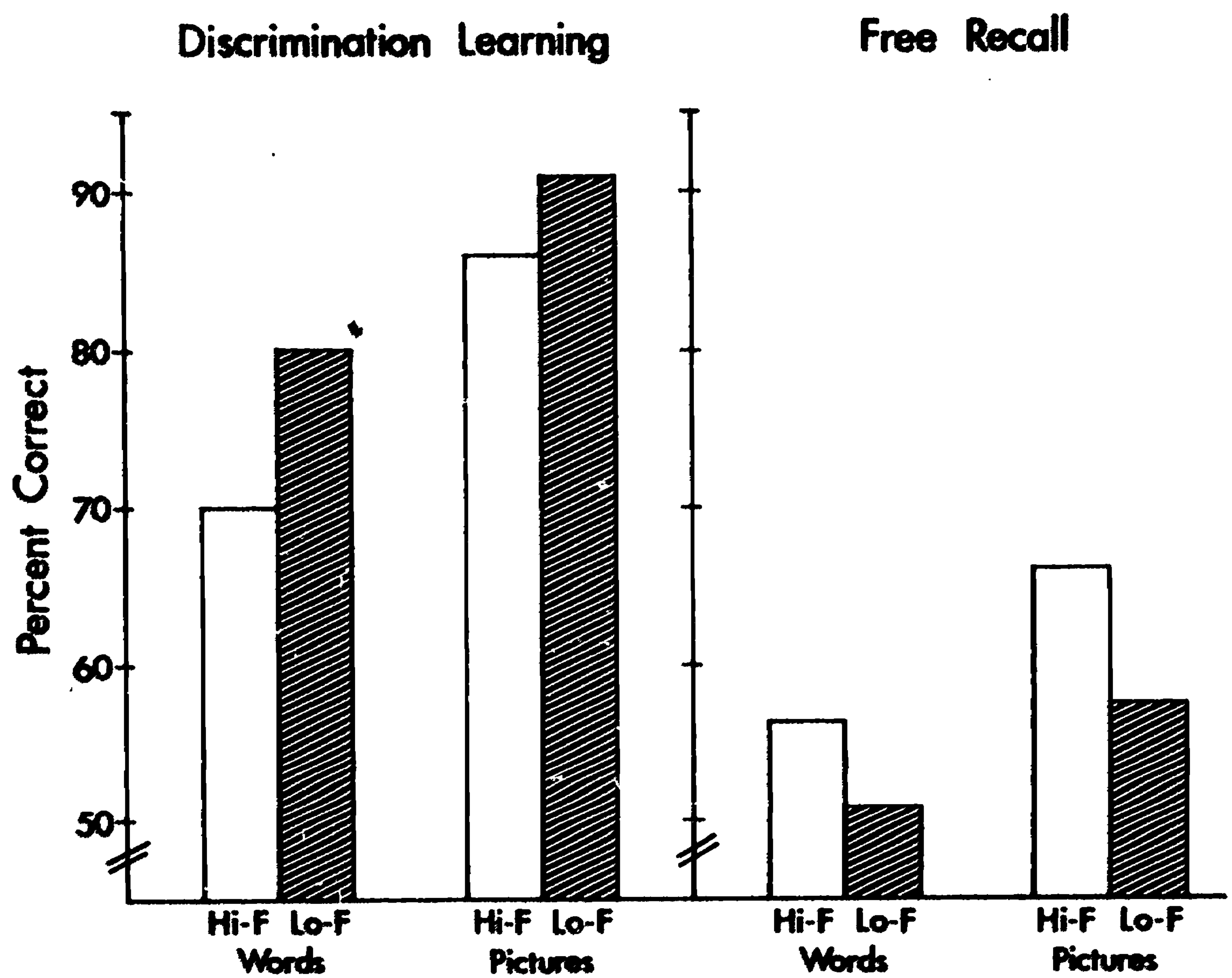

Figure 1. Mean percent correct responses by experimental condition in discrimination learning (Experiment III) and free recall (Experiment IV).

($t = 3.04$, $df = 16$, $p < .01$), with 11 Ss performing better on Lo-F pairs and only 3 Ss performing better on Hi-F pairs (and 3 Ss showing no difference).

Two recent accounts of the picture-word differences found in a variety of learning tasks have been offered by Paivio (1971). The "concreteness" explanation asserts that visual imagery is a powerful determinant of learning efficiency, and that pictures elicit such imagery more directly than do their associated verbal labels. The "dual-coding" explanation, on the other hand, asserts that two internal codes (imaginal and verbal) are more efficient than one, and that pictures are more likely to produce such a dual coding than words--due to the presumed greater propensity of Ss to label pictures spontaneously than to generate visual images for words spontaneously.

Paivio and Csapo (1973) have provided evidence in support of the "dual-coding" (rather than the "concreteness") interpretation of picture-word differences in free recall. While this also seems to be the case in discrimination learning (as determined from some unpublished data of our own), the present study suggests that neither explanation is completely adequate if "background frequency" is ignored. That is, neither can satisfactorily account for discrimination learning differences between high- and low-frequency materials of comparable concreteness (i.e., between high- and low-frequency words or between high- and low-frequency pictures). However, in light of the present finding that pictures with low-frequency labels were better discriminated than were those with high-frequency labels, Paivio's suggestion that pictures are dually encoded (i.e., verbally, along with their nonverbal images) is eminently reasonable in its own right, and should be considered in conjunction with an alternative hypothesis previously offered to account for picture-word differences in discrimination learning (Ghatala, Levin, & Wilder, 1973.)

At the same time, even though a "background frequency" effect was produced with pictorial materials here, its locus is difficult to trace. That is, are low-frequency pictures discriminated better than high-frequency pictures because their respective verbal labels differ in background frequency *or* because their respective object referents differ in background frequency, or both? Certainly the word "giraffe" is encountered less frequently by (North American) Ss than is the word "cat"; yet Ss also encounter more cats than giraffes in their day-to-day existence. Although the present research does not lend itself to a teasing apart of these naturally-correlated factors, it would seem possible to do so.

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V
General Discussion

The present series of experiments indicates that background frequency influences the discrimination learning of verbal materials in a manner prescribed by Weber's Law. More importantly, however, the experiments have shown that the negative relationship between frequency and discrimination learning is evident only for verbal materials which are meaningful to _S_s. The analysis in Experiment II, which showed that only those _S_s in the Lo-F/Hi-M group who actually knew the definitions of the Lo-F/Hi-M words performed significantly better than comparable _S_s in the Hi-F group, appears to be particularly strong evidence in support of the frequency/meaningfulness hypothesis advanced by Ghatala and Levin (1974).

The first two experiments revealed substantial individual differences among children in their knowledge of word meanings, which in turn illustrates the importance of selecting high- and low-frequency words that are not contaminated by differences in meaningfulness. While such individual differences in word knowledge might be expected to be reduced with adult _S_s, it is not unlikely that they still exist (particularly with very low-frequency words) and may be responsible for the equivocal findings concerning frequency effects in verbal discrimination learning which were described earlier. In this regard, Experiment III demonstrated that when words are chosen which are uniformly high in meaningfulness for all _S_s, then the negative relationship between frequency and discrimination learning is clearly apparent.

Experiments III and IV substantiated the finding of opposite effects of word frequency in free recall and discrimination learning (the latter presumably involving recognition memory). Such differential effects of frequency, as well as other variables, have led some (e.g., Kintsch, 1970; Underwood, 1969) to propose that different processes or memory attributes underlie recognition and recall.

Finally, background frequency appeared to influence the discrimination learning of pictures as well as words although, as noted earlier, further research is needed to determine the locus of the frequency effect. Furthermore, in the present study the object referents of all pictures were meaningful to the _S_s. It would be of interest to determine if the discrimination learning of pictures is also moderated by meaningfulness, as has been demonstrated here for verbal materials.

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