# CONTEXT EFFECTS ON FREQUENCY JUDGMENTS OF WORDS AND SENTENCES<sup>1</sup>

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A series of simple sentences (containing a single adjective, a noun, and a verb) were presented on a study trial. Presentation frequency of words comprising sentences was varied by presenting either repetitions of intact sentences or by recombining words from sentences for repetition in new sentences. Thus, modifiers (adjectives and verbs) accompanying repetitions of a given noun were either identical or different for each repetition. Following repetition of intact sentences, frequency judgments were higher when the whole sentences, rather than nouns from sentences, were employed as test items. Sentence frequency judgments were influenced by presentation frequency only when intact sentences were repeated. Increased spacing of intact sentence repetitions enhanced performance, regardless of the type of test item. The effect of increased spacing on noun frequency judgments was reduced by repeating nouns with different modifiers. Implications for a theoretical account of frequency discrimination are considered.

Subjects are capable of judging the frequency with which a given item has been presented in an experimental setting. Ekstrand, Wallace, and Underwood (1966) proposed a theory that is based on S's ability to make frequency discriminations and demonstrated the adequacy of that theory to predict the effect of variables on verbal discrimination learning. A second source of evidence comes from experiments that required Ss to give numerical estimates of presentation frequency (Hintzman, 1969; Underwood, 1969b); with a fair degree of accuracy, judged frequency was found to reflect actual frequency of presentation. The present investigation is concerned with the nature of the memory representation that serves as a basis for frequency judgments.

Underwood (1969a) has suggested that presentation frequency is encoded as an attribute of memory. Repetitions are assimilated to produce a single frequency attribute which is the basis for frequency judgments. This position implies a direct

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<sup>2</sup> Requests for reprints should be sent to Larry L. Jacoby, Department of Psychology, Iowa State University, Ames, Iowa 50010. relationship between frequency judgments and recognition probability during study. If S does not recognize an item as a repetition, the latest presentation could not be assimilated with the earlier one(s) and the frequency attribute would not be incremented. Frequency judgments following study should be highest when conditions are maximal for recognizing repetitions.

Recognition performance has been shown to be a function of spacing of repetitions and the similarity of contexts in which repetitions occur. Light and Carter-Sobell (1970) obtained context effects by testing recognition for nouns following the presentation of adjective-noun pairs. Recognition was higher when the noun was tested in the presence of the adjective (that had accompanied it during study) rather than alone or in the presence of a different adjective. The probability of recognizing a repetition in a continuous recognition task has been consistently shown to be an inverse function of spacing (e.g., Shepard & Teghtsoonian, 1961). In opposition to expectations based on Underwood's position, frequency judgments following study are directly related to the spacing of repetitions (Hintzman, 1969; Underwood, Thus, highest frequency judg-1969b). ments are obtained when repetitions would be least expected to assimilate and increment the value of the frequency attribute,

The effect of change in repetition context on frequency judgments had not been investigated prior to the experiment that is to be reported.

Hintzman and Block (1971) rejected the "strengthlike construct" assumed bv Underwood and proposed a multiple-trace hypothesis as an alternative. The strength hypothesis bases the effect of repetition on the strengthening of a single memory trace, while the multiple-trace hypothesis states that repetitions serve to increase the number of traces formed of the repeated event. Hintzman and Block demonstrated that Ss are capable of discriminating between recent and remote repetitions of the same item. In their experiment, S's judgment of the frequency of an item within a single list was relatively independent of the number of repetitions of that item in another list. This discrimination would not be possible if repetitions summated to yield a single value for a frequency attribute but is easily explained if a multiple-trace hypothesis is adopted. A multiple-trace hypothesis (Madigan, 1969) has also been used to interpret the effect of spacing of repetitions. Increased spacing is assumed to result in a greater number of repetition traces by increasing the uniqueness of contextual and temporal information associated with each trace. If a multiple-trace hypothesis is accepted, it is reasonable to assume that frequency judgments are *derived* at the time of test from the number of retrievable repetition traces (rather than frequency being an attribute that is encoded with an item during study). The multiple-trace hypothesis can then be used to predict a direct relationship between frequency judgdissimilarity of repetition ments and occurrences.

In the present experiment, words were repeated either in the same sentences or in new sentences, and the spacing of sentences was varied. At the time of test, either complete sentences or nouns from the sentences were provided for frequency judgments. The noun test conditions allow an assessment of the effects of spacing and change of context during study. The interaction of these last two variables is of particular interest; if both serve to increase the number of traces formed, the value of one could serve to limit the effect of the other. The sentence test conditions also provide information about the nature of the memory trace. If repeating words in new sentences does not influence frequency judgments of the original sentences, discriminable traces must be formed of sentences which have some words in common. This result would imply that multiple traces are formed of a noun presented in more than one sentence. Additional study conditions involved the substitution of synonyms for words in the original sentences. These conditions were designed to yield further information concerning attributes represented in a memory trace.

## Method

Verbal materials and design .--- Seventy-two unrelated sentences were formed by combining a common adjective, common noun, and common verb with an article (the) and an auxiliary verb (has or was). Similarity of selected words was minimized both within and between grammatical classifications. Concrete nouns were selected from the norms of Paivio, Yuille, and Madigan (1968) and Spreen and Schulz (1966); mean concreteness rating of the selected nouns was 6.60 on a 7-point scale. Twentyfour of the original 72 sentences were critical in that they were central to experimental manipulations; the remaining 48 sentences included 36 sentences that served as fillers in the study list and 12 sentences that were presented only at the time of test. Synonyms of the adjectives, nouns, and verbs comprising the critical sentences were selected from a thesaurus.

Frequency of presentation (2 and 4) and the similarity of modifers accompanying presentations of nouns (identical, similar, and different) were varied. Let  $a_i$ ,  $n_j$ , and  $v_k$  represent an adjective, a noun, and a verb, respectively, with the subscript serving to differentiate words within a grammatical class. A set of three critical sentences might be represented by the combinations  $a_1 n_1 v_1$ ,  $a_2 n_2 v_2$ , and a<sub>3</sub> n<sub>3</sub> v<sub>3</sub>. Repeating a noun with identical modifiers (adjectives and verbs) resulted in the repetition of intact critical sentences. When nouns were repeated with different modifiers, words from critical sentences were recombined so that each repetition of a noun occurred in a new sentence; frequency of repetition of words comprising critical sentences was the same as would have resulted from repeating nouns with identical modifiers. For example, the three critical sentences and the three completely different combinations of words comprising critical sentences (a1 n2 v3, a2 n3 v1, and

 $a_3 n_1 v_2$ ) were presented to produce repetition of nouns with different modifiers at Frequency Level 2. Sentences containing repetitions of nouns with similar modifiers were constructed by substituting synonyms for the adjectives and verbs contained in critical sentences. If "The weary slave was working" was a critical sentence that represented Frequency Level 4, repetition of the noun with similar modifiers resulted in the presentation of the following sentences: "The tired slave was laboring," "The exhausted slave was toiling," and "The fatigued slave was busy." Additional conditions were identical to those previously described with the exception that synonyms, rather than repetitions, of the nouns contained in critical sentences were presented; frequency level dictated the number of synonyms of a noun that were presented. If the critical sentence "The weary slave was working" represented the noun-synonym rather than the repetition condition, the first, second, and third repetition of "slave" was replaced by the presentation of "serf," "peon," and "servant." The experimental conditions then can be conceptualized as a  $2 \times 2 \times 3$  factorial with 2 levels of frequency (2 and 4), 2 levels of similarity of the nouns (repetition and synonym) and 3 levels of similarity of modifiers (identical, similar, and different). Within a list, each of the 12 combinations of experimental conditions was represented by 2 critical sentences, resulting in a set of 24 critical sentences. The manipulation of similarity of nouns and similarity of modifiers required the construction of 48 (12 for Frequency Level 2 and 36 for Frequency Level 4) additional sentences, including repetitions of critical sentences. Between lists, critical sentences were rotated through all 6 combinations of similarity of nouns and similarity of modifiers so that effects of differences between critical sentences were partially controlled.

Spacing of repetitions or synonyms of a noun, and type of test item were varied between lists. Sentences in which a given noun was represented were either contiguous or separated by the presentation of an average of 3 or 10 intervening sentences. Spacing in Cond. 3 and 10 was allowed to vary 1 or -1 intervening sentence to prevent the necessity of repeating series of sentences in the same order. The three levels of spacing (0, 3, and 10) and two test conditions (sentences and nouns) were factorially combined with the within-list manipulations.

Lists and test booklets.—A study list contained 60 unrelated sentences among 136 sentence presentations. A 20-item primacy buffer and a 20-item recency buffer occupied Serial Positions 1 through 20 and 117 through 136, respectively. Each buffer contained 11 unrelated sentences: 8 sentences presented once, 2 sentences presented three times each (repetitions of one of these sentences were massed while repetitions of the other were spaced), and 1 sentence presented six times (repetitions were massed). Presentations of the 24 critical sentences and 48 sentences derived from critical sentences occurred within Serial Positions 21 through 116; additional sentence presentations within these positions included 12 sentences that were presented once and 2 sentences that were presented six times each (repetitions were massed in Spacing Cond. 0 and spaced in Cond. 3 and 10).

Test booklets contained either sentences or nouns taken from the sentences. Each booklet contained 56 test items: 24 provided by the critical sentences, 12 from sentences with a single study presentation that had occurred within Serial Positions 21 through 116, 12 from sentences that were not in the study list, 4 from filler sentences that had been presented three times, and 4 from filler sentences that had been presented six times. Order of the test items was randomized with the restriction that each combination of frequency, similarity of the noun, and similarity of modifiers be represented equally on each page of the booklet. Test booklets contained four pages with 14 test items on each page.

Subjects and procedure.—Introductory psychology students were tested in 18 groups, ranging in size from 6 to 8 Ss; at least 3 Ss within each group were assigned to each of the two types of test (sentences and nouns). Some Ss were randomly eliminated for purposes of analysis so that each of the six combinations of spacing and type of test was represented by 18 Ss.

Prior to the study trial, Ss were informed that they would be shown a list of sentences containing repetitions of complete sentences and repetitions of words from other sentences. In addition, they were informed that the meanings of some of the sentences, and words within different sentences, would be similar. The Ss were led to expect a test of memory; however, the nature of the impending memory task was not specified.

Sentences were presented at a 5-sec. rate by means of an internally timed Kodak Carousel projector. After all 136 sentences had been presented, test booklets were distributed and Ss were instructed to write in the blank following each test item their estimate of the number of times that item had occurred in the series of sentences they had just seen. The Ss were allowed to complete the test booklet at their own pace.

Scoring and analyses.—Each of the 12 combinations of within-list conditions was adjusted for false positive rate by subtracting from each S's score S's mean judgments for the 12 zero-frequency test items. An initial analysis of these data indicated that the variance in the noun test condition was over three times as large as the variance in the sentence test condition. For this reason, data were analyzed separately for the noun and sentence test conditions; each analysis employed a 2 (Frequency Level)  $\times$  2 (Similarity of Nouns)  $\times$  3 (Similarity of Modifiers)  $\times$  3 (Spacing) analysis of variance with repeated measures on the first three factors.

#### RESULTS

Sentences.—Table 1 presents means from the significant, F(2, 72) = 23.01, p < .001, triple interaction of frequency, similarity

### TABLE 1

MEAN FREQUENCY JUDGMENTS OF SENTENCES AS A FUNCTION OF FREQUENCY, SIMILARITY OF THE NOUN, AND SIMILARITY OF MODIFIERS

	Similarity of the noun							
Modifiers	Repetition				¥	Synonym		Ī
	0	1	2	4		2	4	
Identical Similar Different	.05	.68	1.67 .80 .80	3.35 .98 .96	2.51 .89 .88	.97 .77 .73	1.11 .71 .83	1.04 .74 .78
$\bar{X}$			1.09	1.76	1.43	.82	.88	,85

Note.—Frequency Level 0 used for correction for false positive rate.

of the nouns, and similarity of modifiers. The mean frequency judgments of sentences that were presented once during study is included in Table 1 for purposes of comparison but did not enter into the analysis. Repetition of nouns with identical modifiers resulted in frequency judgments that were higher than those produced by any other combination of similarity of nouns and similarity of modifiers. When synonyms were presented, there was a small effect of similarity of modifiers; frequency judgments were highest when modifiers were identical. Increased frequency of presentation resulted in an increase in frequency judgments only when nouns were repeated with identical modifiers.

The analysis of variance confirmed the description of the results given above. The effect of similarity of the nouns, F(1, 36) = 92.01, the effect of similarity of modifiers, F(2, 72) = 102.27, and the interaction of similarity of the noun with similarity of modifiers, F(2, 72) = 40.05, all ps < .001, were all highly significant. The main effect of frequency, F(1, 36) = 36.83, and the interactions of frequency with similarity of the nouns, F(1, 36) = 20.85, and similarity of the modifiers, F(2, 72) = 23.01, all ps < .001, were also significant. Means for these significant effects are included in Table 1.

Spacing had an effect only when intact sentences were repeated; i.e., nouns were repeated with identical modifiers. Mean frequency judgments resulting from repetition of a noun with identical modifiers were 1.67, 2.80, and 3.05 for Spacing Levels 0, 3, and 10. The analysis of variance showed the following factors to be significant: the main effect of spacing, F(2, 36) = 4.23, p < .05, the interaction of spacing with similarity of modifiers, F(4, 72) = 7.39, p < .01, and the triple interaction of spacing with similarity of nouns and similarity of modifiers, F(4, 72) = 2.52, p < .05.

Nouns.—Table 2 presents means from the significant, F(1, 36) = 44.42, p < .001,interaction of frequency with similarity of Means from the significant the nouns. main effects of frequency, F (1, 36) = 88.92, and similarity of the nouns, F(1, 36) = 69.87, both ps < .001, appear in Table 2 as column and row means. The frequency judgment of nouns that were presented once during study did not enter into the analysis but was included in Table 2 for purposes of comparison. Although frequency had a larger effect when repetitions of the noun were presented, an increase in the number of either synonyms or repetitions resulted in an increase in frequency judgments.

Frequency judgments were higher when modifiers were similar (1.78) rather than identical (1.56) or different (1.54), F(2, 72)= 3.66, p < .05. Mean frequency judgments as a function of similarity of the noun, similarity of modifiers, and spacing are presented in Table 3. Degree of spacing was an effective variable only when repetitions of the noun were presented, F(2, 36)= 4.16, p < .05; means from the interaction of spacing with similarity of the nouns appear as column means in Table 3.

TABLE 2

MEAN FREQUENCY JUDGMENTS AS A FUNCTION OF SIMILARITY OF NOUN AND FREQUENCY

Similarity						
of noun	0	1	2	4	л	
Repetition Synonym	.26	.66	1.28 1.00	2.79 1.43	2.04 1.22	
$ar{X}$			1.14	2.11	1.63	

Note.—Frequency Level 0 was used to correct for false positive rate.

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MEAN FREQUENCY JUDGMENTS OF NOUNS AS A FUNCTION OF SPACING, SIMILARITY OF NOUN, AND SIMILARITY OF MODIFIERS

	Similarity of the noun							
Modifier	Repetition lag			Ţ	Synonym lag			
	0	3	10	Λ	0	3	10	^
Identical Similar Different	1.13 2.10 1.80	1.91 2.12 1.69	2.62 2.68 2.28	1.89 2.30 1.92	1.27 1.23 1.17	1.14 1.07 .99	1.32 1.51 1.33	1.24 1.27 1,16
$\bar{X}$	1.68	1.91	2.53	2.04	1.22	1.07	1.35	1,21

The interaction of spacing with similarity of modifiers, F(4, 72) = 11.36, p < .001, was analyzed separately for conditions that received repetitions of the nouns and found to be highly significant. Increasing the spacing of repetitions from 0 to 10 resulted in higher frequency judgments within each of the levels of similarity of modifiers; however, the effect of spacing was largest when modifiers were identical. When repetitions were contiguous, identical modifiers produced frequency judgments that were substantially lower than those produced by either similar or different modifiers.

The interaction of spacing, similarity of modifiers, and frequency was significant, F(4, 72) = 3.13, p < .05. In general, it appeared that spacing was most effective when modifiers were identical and frequency level was 4.

#### DISCUSSION

The first issue concerns the manner in which repetitions are represented in memory. The noun test conditions provided data that are consistent with a multiple-trace hypothesis: the effect of spacing of repetitions on noun frequency judgments was substantial only when modifiers were identical. This interaction is similar to one predicted and observed by Madigan (1969) in a study of recall. Madigan assumed that either increased spacing or decreased similarity of modifiers could produce a greater number of discriminable repetition traces. Since the total number of traces cannot exceed the number of presentations, the effect of one variable is constrained by the value of the other. A strength hypothesis can

predict the effect of spacing (cf. Landauer, 1969) but does not necessarily predict the interaction of spacing with similarity of modifiers.

More direct evidence for a multiple-trace hypothesis comes from the sentence test conditions. Frequency judgments of sentences were influenced only by the number of repetitions of intact sentences; repeating words in new sentences did not increase apparent frequency of the original. This result suggests that words comprising a sentence combined to form a sentence trace and that each occurrence of an individual word was marked for context by its inclusion in a sentence trace. Thus. repeating a noun in different sentences must have resulted in multiple noun traces that could be differentiated on the basis of context. Results of the present investigation still allow a theory (cf. Bower, 1970) that states repetitions can increase either the strength or number of traces. However, strength theories without this modification are inadequate to account for the results.

Are frequency judgments based on an encoded attribute (Underwood, 1969a) or derived at the time of test? Either position could be made compatible with an increase in number of traces resulting from repetition. However. only the attribute hypothesis need assume that repetition can serve a function similar to the strengthening of a trace. Ekstrand et al. (1966) suggest that Ss are capable of discriminating experimental from the extraexperimental frequency of a word. This allows more than one frequency attribute to be stored with a single word and could be extended to permit a separate attribute for each discriminable repetition trace. The manner in which frequencies are assimilated, however, is difficult to conceptualize. If frequency judgments are based on an encoded attribute, presenting a noun in four different sentences must result in a frequency attribute for each sentence and a separate attribute indexing the total number of times the noun was presented; otherwise, frequency judgments of nouns would not have differed from those of sentences in the present investigation. It can be seen that an analysis of this type could soon become unwieldly. There must be a frequency attribute for each discriminable trace plus frequency attributes for the sums within possible partitions of repetition traces. It would seem more reasonable to state that frequency judgments are derived at the time of test. The "situationality" of frequency judgments would, then, be largely

determined by instructions; specification of the situation in terms of contextual and temporal restrictions determines which traces are to be considered relevant to the frequency judgment.

If it is assumed that frequency judgments are derived, emphasis is placed on storage and retrieval processes. Frequency estimates should depend on the number of discriminable traces that are retrievable at the time of test. As discussed earlier, spacing and similarity of modifiers might influence storage by increasing the number or discriminability of traces. Retrieval processes can be investigated by treating groups identically during training and then varying test conditions. Investigations employing this technique (Light & Carter-Sobell, 1970; Tulving & Thomson, 1971) have found highest recognition when conditions of study and test were most similar. Following repetitions of complete sentences in the present investigation, frequency judgments were higher for sentence (2.51) than for noun (1.89) test items (variances were 5.7 and 16.7, respec-Frequency judgment tasks do not tively). differ from other memory tasks in that performance is a function of both storage and retrieval of mnemonic information.

Performance in the synonym conditions was of secondary interest. Presenting synonymous nouns had very little influence on frequency judgments, and performance in similar modifier conditions did not differ from that in conditions receiving completely unrelated modifiers. Degree of spacing also had no effect when synonyms were presented. This general lack of an effect of variables may reflect the quality of synonyms that were employed. However, after trying to select synonyms, one loses faith in the existence of "true" synonyms. The present results would probably not be changed by employing another sample. Apparently, retained information is usually sufficient to allow S to discriminate between the presentation of a synonym and a repetition.

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