DOCUMENT RESUME

ED 264 310 TM 860 021

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TITLE	Do We Process Frequency Information Automatically?
PUB DATE	Mar 85
NOTE	27p.; Paper presented at the Annual Meeting of the Eastern Psychological Association (Boston, MA, March 21-24, 1985).
PUB TYPE	Speeches/Conference Papers (150) -- Reports - Research/Technical (143)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Advance Organizers; Cognitive Processes; *Encoding (Psychology); Incidental Learning; Intentional Learning; Language Processing; *Learning Processes; Letters (Alphabet); Memorization; Pattern Recognition; Receptive Language; *Recognition (Psychology); Short Term Memory; *Word Frequency; Word Lists; *Word Recognition
IDENTIFIERS	*Automatization; Nonsense Words

ABSTRACT

Two criteria for the automatic encoding of learning, instructional manipulation, and stimulus characteristics were studied in subjects who judged the frequency of occurrence of words, letters, and nonwords. In Experiment 1, six word lists were constructed with varying frequency of alphabet letters. A variety of instructions were presented (whether to study word frequency or letter frequency). Some subjects were administered the expected task, and others were surprised with a different test. Results confirmed that subjects were more accurate when they were told to attend to letter frequency (the intentional condition) than word frequency (the incidental condition). In the word frequency task, subjects who were instructed to remember word frequency performed better than those instructed to remember letter frequency, the distractor. Experiment 2 varied the meaningfulness of letter strings (some were words and some were not) and high versus low probability of occurrence. In general, judgment of frequency increased as did actual frequency. As frequency increased, so did the differences in judgments between meaningful versus nonsense words, and between high versus low probability words. It was concluded that frequency information was processed automatically, but varied according to the type of material presented. (GDC)

ED264310

Paper Presented at the Eastern Psychological Meetings, 1985

DO WE PROCESS FREQUENCY INFORMATION AUTOMATICALLY?

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If we examine our life experiences, it often seems that we have readily available to us information about the frequency with which events occur. That is, we do not seem to rely on any real computation of the number of times we were likely to have experienced some event -- rather, we seem to immediately know the approximate number of times that event occurred.

In fact, many laboratory studies are in keeping with these observations of personal experiences. For example, researchers have manipulated the frequency of simple stimuli like dots (Erlick, 1961) as well as more complex and meaningful stimuli like words (Hasher & Chromiak, 1977; Hintzman, 1969), actions (Kausler & Hakami, 1983), pictures (Hasher & Zachs, 1979; Johnson, Taylor, & Raye, 1977) and sentences (Burnett & Stevenson, 1979; Gude & Zeichmeister, 1973). Repeatedly, in studies such as these, people are quite good at keeping track of the frequency with which events occur in the laboratory, generally referred to as situational frequency judgments. These findings suggest a general disposition to remember frequency information.

In part, because these situational frequency judgments are quite good for a variety of materials and under a variety of circumstances, Hasher and Zachs suggested in 1979, and again this year, that frequency information is encoded automatically. They offer several criteria for the automatic encoding of information, criteria summarized in Table 1.

Insert Table 1 about here

First, frequency judgments seem to be impervious to instructional manipulations (e.g., Flexser & Bower, 1975; Hasher & Chromiak, 1977). Thus, if subjects are told to remember the frequency with which words occur (referred to as intentional instructions), they do no better than other subjects told to prepare for a memory test without specific mention of a test on frequency (referred to as incidental instructions). Secondly, frequency judgments do not seem to improve with practice (Hasher & Zachs, 1979; 1985). Third, processing frequency information is thought to have a minimal impact on concurrent tasks that are more effortful because automatic processing does not interfere with other types of processing (Hasher & Zachs, 1979). Finally, the absence of developmental trends in frequency judgments -- subjects as young as 6 and as old as 70 often perform as well as college students (Attig & Hasher, 1980; Goldstein, Hasher, & Stein, 1983; Hasher & Zachs, 1979; Johnson, Raye, Hasher, & Chromiak, 1977; Kausler, Litchy, & Hakami, 1984) -- is used as a fourth criterion for an automatic process.

We have initiated a program of research to investigate the degree to which the criteria listed in Table 1 are, in fact, characteristic of automatic processing. Today I will discuss our first set of studies that were designed to examine the potential effects of instructional manipulations on frequency judgments.

In addition to our interest in the effects of instructions, a second question motivated our studies. We had a hunch that some events -- for example, words -- lend themselves more readily to processing for frequency than other events -- for example, letters embedded in words. Hasher and Zachs (1979; 1985) do not directly address the question of the impact of the stimulus characteristics on frequency judgments. And, in fact, there are very few studies examining the effects of types of materials on frequency judgments within the same experimental design. This may reflect the strength of the assumption that humans process the frequency of a variety of events, and that frequency information has some special status in memory (Hasher & Zachs, 1979; Hintzman, 1976; Hintzman, Nozawa, & Irmscher, 1982; Johnson, 1977) -- an assumption that we think is implicit in Hasher & Zach's model. In our two experiments, we measure subjects' sensitivity to word frequency, their sensitivity to the frequency of constituent letters of words and their sensitivity to the frequency of nonmeaningful events, to see whether some of these events lend themselves more readily to processing for frequency.

Experiment 1

Materials. In Experiment 1 a pool of words was selected from the Paivio, Yuille, & Madigan (1971) norms, all of which were high in frequency as well as concreteness. Six lists were constructed so that the 26 letters of the alphabet varied within each list over a range of 0 to about 70 times.

Design and Procedure. Table 2 highlights the two major groups that I want to discuss. On the left side, Group 1 included 60 subjects who were first instructed to attend to _word frequency_. Subgroups of 10 subjects were subsequently shown 1 of 6 word lists, and then surprised with a _letter frequency judgment task_. For example, they were asked to quickly estimate the number of times the letter c occurred in the entire list of words. For each letter frequency test, subjects were briefly shown the 26 letters of the alphabet, one at a time, in random order.

Insert Table 2 about here

After judging the frequency with which each of the 26 letters had been presented, we told subjects that the real purpose of the experiment was to see if they were better at keeping track of letter frequency when they were forewarned about the letter frequency test. We further explained that the only way to do this was to first surprise them with a letter frequency task so as to compare performance under informed and uninformed conditions. Subjects were then given specific instructions to attend to _letter frequency_, they were shown a second list of words, and, then, in fact, they made letter frequency judgments. Finally, much to their surprise, subjects were given a list of words comprised of words from List A and List B as well as high frequency distractors, and were asked to judge the frequency with which each word had been presented.

Scanning down the right side of the slide, the second major group is represented. Sixty other subjects were first told to attend to letter frequency, and subgroups of 10 subjects were shown 1 of 6 possible lists. They were told the purpose of the study was to see if judgments would improve with practice. This served to justify the purpose of the second letter frequency task. Subjects were again given letter frequency instructions, shown a second list of words, and they made letter frequency judgments. Finally, to their surprise, these subjects also made word frequency judgments at the end of the session.

The six different word lists were counterbalanced across subjects so that each occurred equally often under all instructional manipulations.

Results

Letter Frequency Judgments

First, I want to report on the letter frequency judgments. The results of several planned comparisons involving letter judgments emphasize the robustness of the instructional manipulation. We compared letter frequency judgments for subjects in Group 1, looking at judgments under intentional and incidental instructions; subjects were more accurate when they were told to attend to letter frequency (intentional condition) than when they were told to attend to word frequency (incidental condition). However, one could argue that these differences in accuracy were due to practice effects rather than the instructional manipulation since the intentional instructions always followed the incidental instructions. Thus, a stronger test is provided by the comparison of letter frequency judgments corresponding to the first word list for Group 1 and Group 2, judgments made under incidental and intentional letter frequency instructions, respectively.

Collapsing across the six lists, we compared the average performance on letters whose frequency was 0, relatively low or relatively high. Figure 1 summarizes the letter frequency judgments. Judgments of letter frequency increased with presentation frequency, suggesting that subjects were sensitive to frequency information, $F(2,236) = 412$, $MSe = 34.9$, $p < .001$. But, as is also shown in Figure 1, there were substantial differences in judgments under intentional and incidental instructions as this slide shows, $F(1,18) = 15.7$, $MSe = 129.5$, $p < .001$, and, this difference was greater at greater frequency levels, $F(2,236) = 31.17$, $p < .001$. This general pattern was evident when each list was examined separately. In addition, analyses of absolute errors showed that subjects were generally more accurate when making frequency judgments under intentional instructions compared with incidental ones.

Insert Figure 1 about here

Word Frequency Judgments

Both the within and between subjects comparisons involving letter frequency judgments showed large differences in the two instructional conditions, especially at greater frequencies. Now let's consider the effects of instruction on word frequency judgments. In some sense, these effects were more surprising than the effects of instructions on letter frequency judgments.

Remember that subjects in Group 1 were told to pay attention to word frequency when they were shown the first list. But they then made two sets of letter frequency judgments - for both the first and second list. Subjects in Group 2 never expected to make word frequency judgments, and, actually, for these subjects, the intentional letter frequency instructions served as distractor exercises with respect to word frequency.

As with the letter frequency judgments, we first compared the word frequency judgments for Group 1 under intentional and incidental conditions. As you can see in Figure 2, mean absolute errors were lower under intentional instructions compared with incidental instructions, $\underline{F}(1,59) = 10.07$, $\underline{MSe} = 2.01$, $\underline{p} < .002$. This difference in errors increased with increases in presentation frequency, $\underline{F}(3,177) = 3.99$, $\underline{MSe} = 1.44$, $\underline{p} < .009$.

Insert Figure 2 about here

We then compared word frequency judgments on the first word list for Group 1 and Group 2. Again, as seen in Figure 3, the error data are telling in their demonstration of the effects of instruction. Subjects given instructions to remember word frequency did better than subjects given instruction to remember letter frequency, $\underline{F}(1,118) = 227.23$, $\underline{MSe} = 18.83$, $\underline{p} < .002$; and this difference was greater at higher frequency levels, $\underline{F}(4,472) = 4.93$, $\underline{MSe} = 3.59$, $\underline{p} < .001$. Thus, with both word and letter frequency judgments, subjects were more accurate when they were instructed to attend to the particular frequency information of interest.

Insert Figure 3 about here

Experiment 2

In our second experiment, we manipulated two characteristics of verbal stimuli. Materials were all five-letter strings differing in terms of their meaningfulness -- they were words or nonwords -- and differing in terms of their probability of occurence in the English language -- high vs low. Table 3 summarizes the characteristics of the stimuli that were manipulated.

Insert Table 3 about here

Design and Materials. The high and low frequency words contained virtually the same letters, and their average concreteness ratings were comparable and high. The nonword letter strings were constructed by using the pool of letters from the words. Five letter nonwords were created by placing letters in positions in which they occur with high frequency in the English language for high probability nonwords and in positions in which they occur with low frequency in the English language for low probability nonwords. These target items occurred equally often at one of seven frequency levels ranging from 1 to 24.

Procedure. Subjects were told that they would see a number of different stimuli, some occurring more often than others, and they were told that they would be tested on frequency.

Results

Analysis of variance showed that judgments of frequency increased with actual presentation frequency, as shown in Figure 4. More importantly, you can also see that the differences in the frequency judgments for meaningful and nonmeaningful material increased with increases in presentation frequency. Though it is not shown in this figure, a similar pattern was found for the relationship between probability and frequency; differences in the frequency judgments for high and low probability material increased with increases in presentation frequency.

Insert Figure 4 about here

Underwood (1971) and others (e.g., Hintzman & Stern, 1984) have suggested that the process underlying frequency judgments is similar to that involved in recognition judgments. If the processes for these two judgments are related, one would predict that subjects' performance in frequency judgment and recognition tasks would be similar. We know that subjects recognize low frequency words better than high frequency words -- and this effect is referred to as <u>word frequency effect</u> (Glanzer & Bowles, 1976; Zeichmeister & Nyberg, 1982). If these judgment processes are related, one would also expect that subjects would be better able to estimate the frequency of low frequency words compared with high frequency words. Such was the case in our second study. The results of planned comparisons indicated that errors on low frequency words (M = 2.63) were significantly lower than errors on high frequency words (M = 4.04), $F(1,26) = 5.45$, $MSe = 17.81$, $p <$

.03. This difference in frequency judgments for high and low frequency words is consistent with findings recently reported by Rao (1983).

One possible explanation for the word frequency effect and the superior frequency judgments for low frequency words is that subjects are more sensitive to the occurence of less familiar items. This would lead one to expect that the nonwords in our study would be at an advantage relative to both the low and high frequency words. That this was not the case (the mean errors on nonwords were 4.35 and 4.57 for high and low probability letter strings, respectively) suggests that the word frequency effect does, in fact, require that the stimuli be meaningful to the subjects. Were low frequency words sufficiently obscure, based on our data, we would expect the word frequency effect to be minimized.

Discussion

What are the most important findings in our two studies? First, some characteristics of stimuli have consequences for frequency judgments. It is clear that meaningfulness is important since subjects were more accurate when estimating the frequency of words compared with nonwords. The frequency of stimuli with which subjects have had little or no experience (here, nonmeaningful letter strings) are not processed as readily as those with which subjects are familiar. These findings argue against the notion that the encoding of frequency information is a simple unitary process in which any and all events increment frequency counters in an automatic fashion.

Secondly, Experiment 1 shows quite clearly that instructional manipulations affect both letter and word frequency judgments. Given the importance attached to the absence of instructional manipulations by a number of researchers (e.g., Hintzman, Kausler) including Hasher & Zachs, one might think that our finding of significant instructional effects is aberrant. In fact, instructional effects on frequency judgments have often been found (e.g., Fisk & Schneider, 1984; Kellogg, 1983; Rowe, 1974). Green (1984), for example, has recently reported large instructional effects on frequency judgments. Sometimes the very researchers who support the idea that this criterion is an index of automaticity, also find instructional effects though they tend to minimize them (e.g., Hasher & Chromiak, 1977; Zachs, Hasher, & Sanft, 1982).

In conclusion, we agree that frequency information is often processed automatically. Our own data are consistent with this idea, in that subjects were sensitive to differences in frequency in all of the conditions in both studies. However, our findings also show that some materials <u>do</u> lend themselves more readily to the automatic encoding of frequency information. Finally, and most importantly, our data suggest that the inclusion of the absence of an instructional effect as one criterion for automaticity seems premature.

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Hasher & Zacks

Automaticity Criteria

Intentional vs. Incidental

Instructions and Practice

Interference

Developmental Trends

Table 1

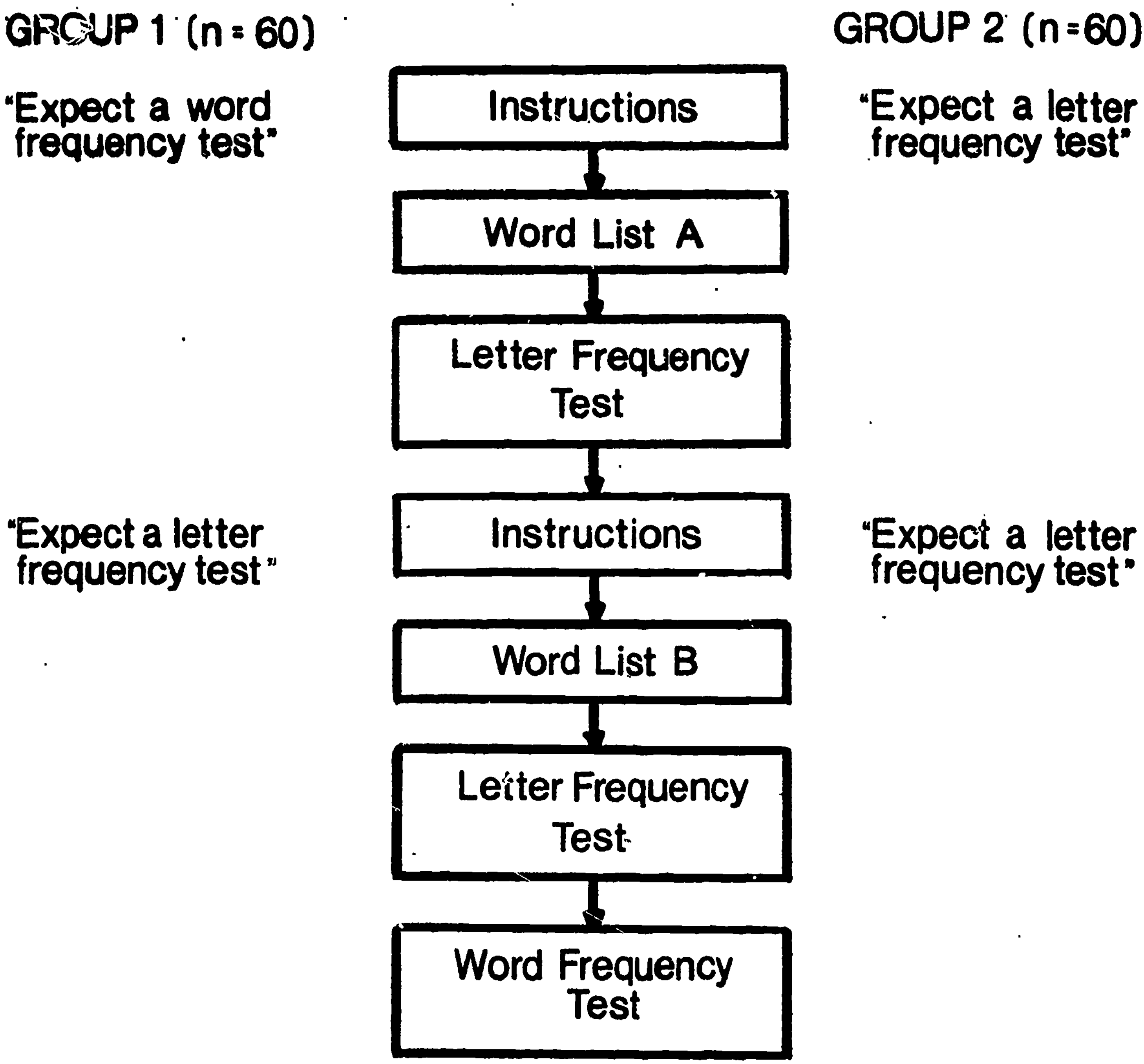

GROUP 1 (n = 60)
GROUP 2 (n = 60)
"Expect a word frequency test"
Instructions
"Expect a letter frequency test"
Word List A
Letter Frequency Test
"Expect a letter frequency test"
Instructions
"Expect a letter frequency test"
Word List B
Letter Frequency Test
Word Frequency Test

Table 2

		MEANINGFULNESS	
		HIGH (WORDS)	LOW (NONWORDS)
PROBABILITY OF OCCURENCE	HIGH		
	LOW		

INDEPENDENT GROUPS DESIGN
FULLY INFORMED
NUMBER PER CELL = 14

Table 3

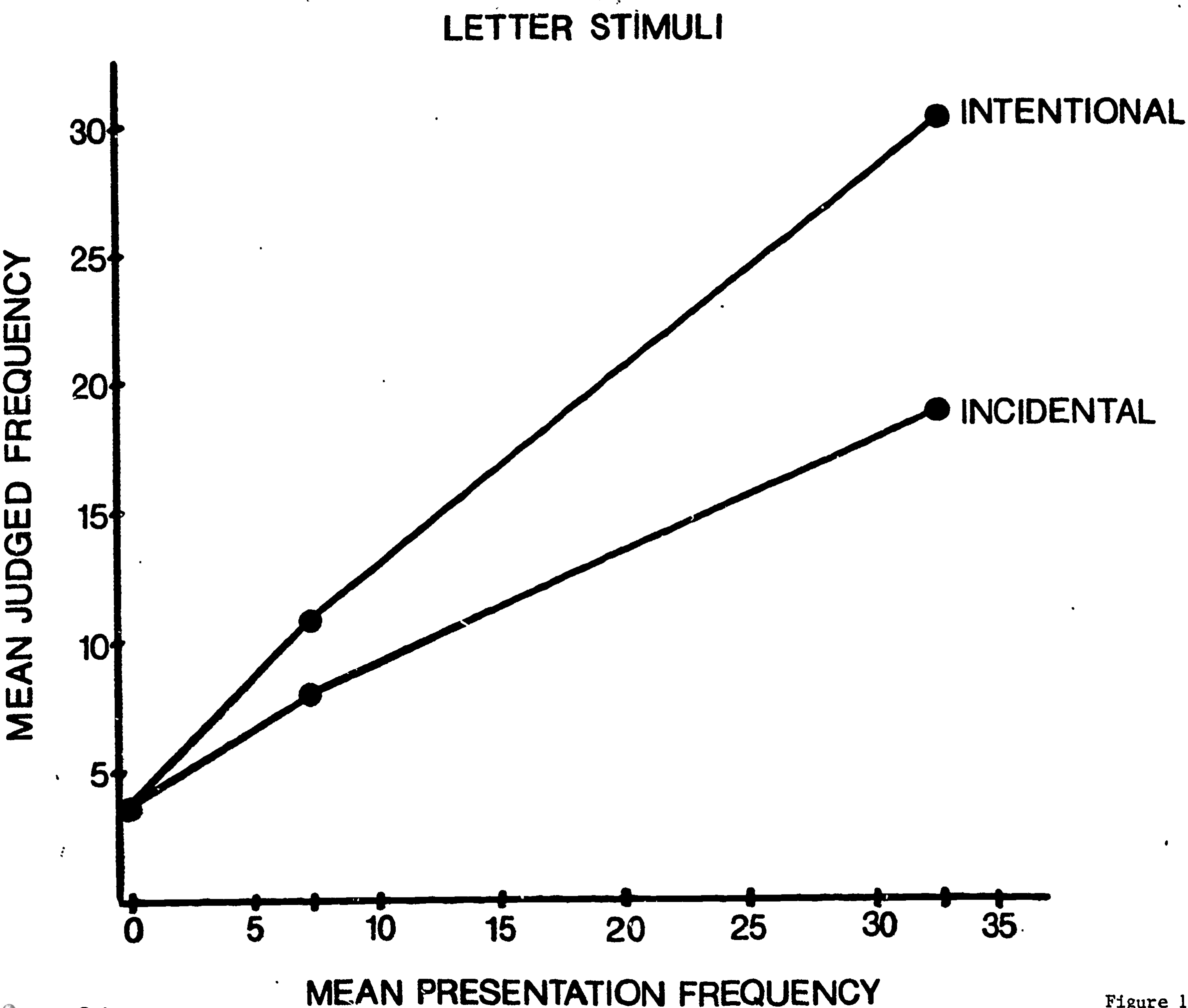
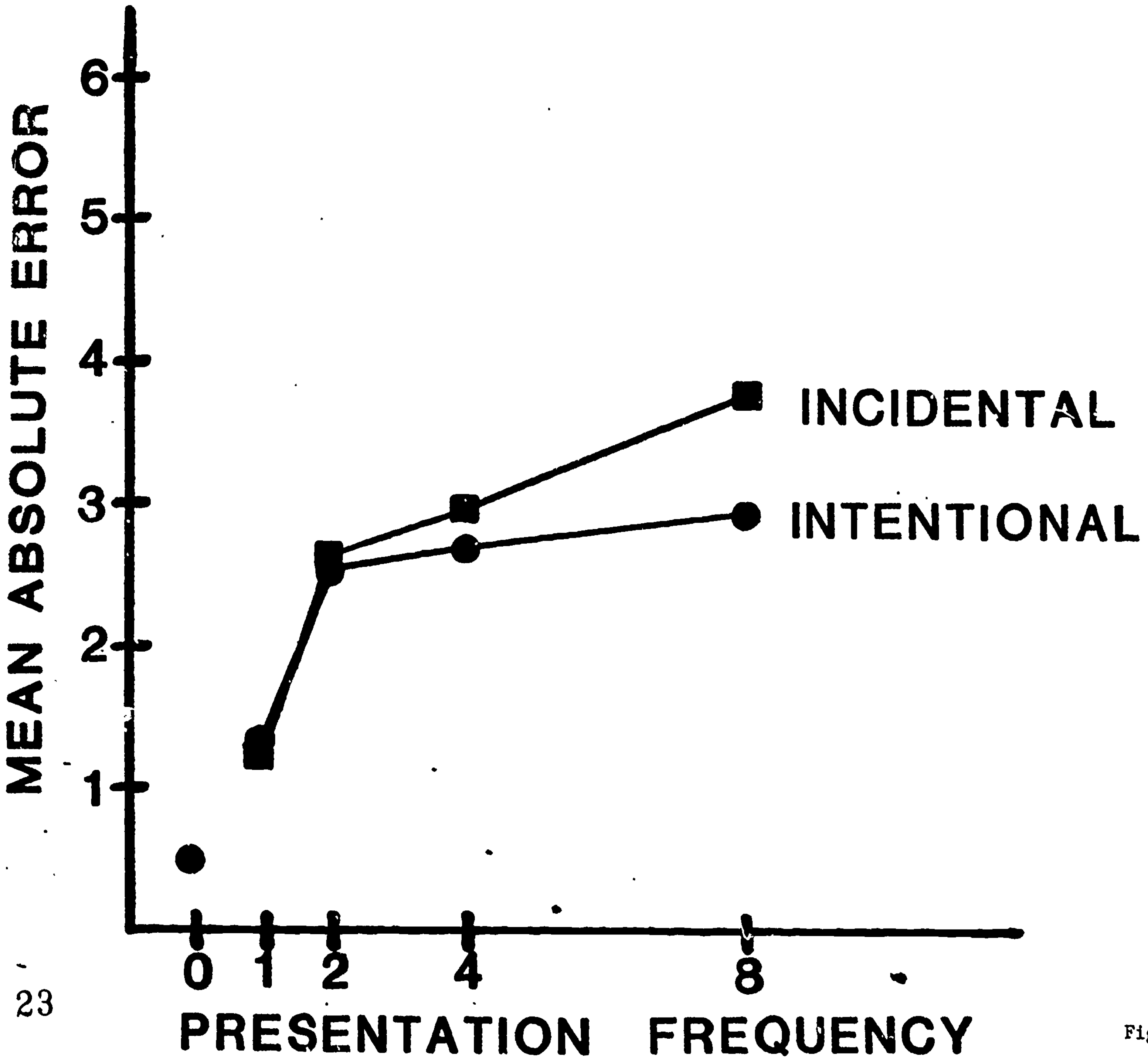

LETTER STIMULI
INTENTIONAL
INCIDENTAL
MEAN JUDGED FREQUENCY
30
25
20
15
10
5
0
5
10
15
20
25
30
35
MEAN PRESENTATION FREQUENCY

Figure 1



MEAN ABSOLUTE ERROR
6
5
4
3
2
1
INCIDENTAL
INTENTIONAL
0
1
2
4
8
PRESENTATION FREQUENCY

Figure 2

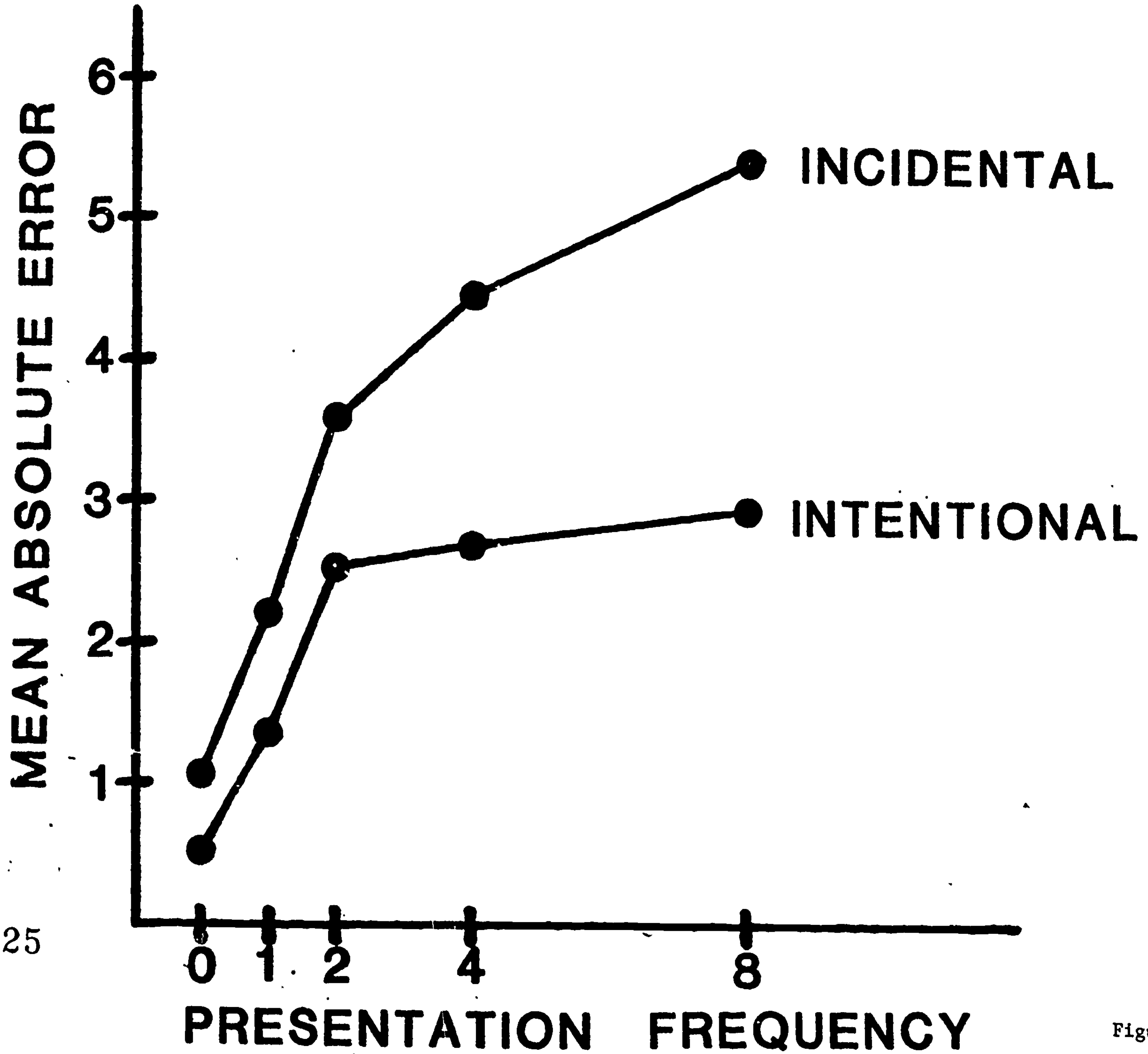

MEAN ABSOLUTE ERROR
6
5
4
3
2
1
INCIDENTAL
INTENTIONAL
0
1
2
4
8
PRESENTATION FREQUENCY

Figure 3

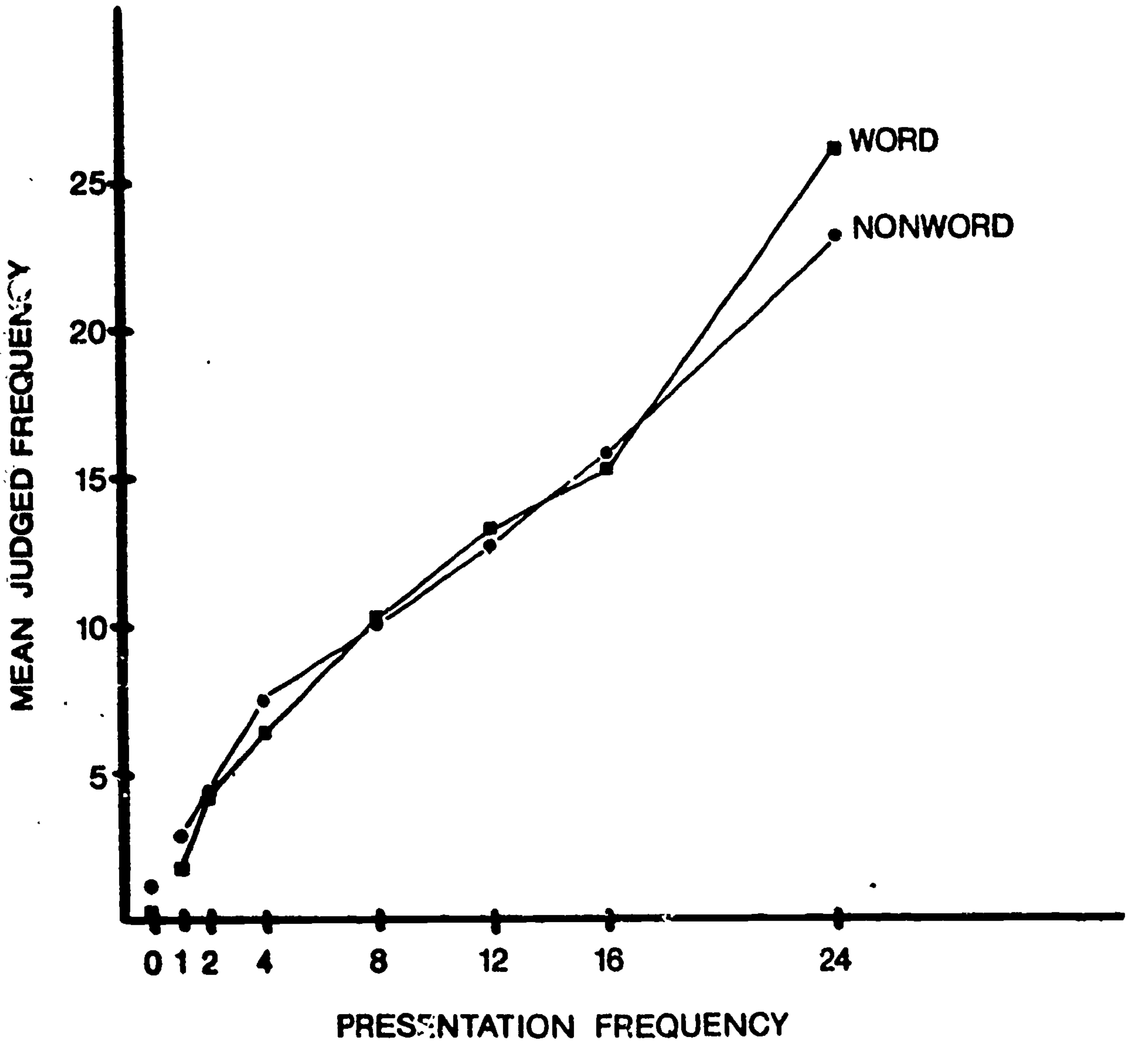

WORD
NONWORD
MEAN JUDGED FREQUENCY
25
20
15
10
5
0 1 2 4 8 12 16 24
PRESENTATION FREQUENCY

Figure 4