An Investigation of Judgments of Category Frequency

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Two experiments investigated the kinds of frequency information that people can remember and individual differences in accuracy of reporting frequency. The task involved presenting individual instances of natural categories and requiring subjects to give absolute estimates of the number of times each category had occurred. In the first experiment, the variability of items was manipulated to assess whether subjects base their estimates on a direct memory access or on a retrieval and mental count of (Continued)

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individual instances. A second experiment evaluated subjects' capability to
report category frequency at two levels of conceptual organization and whether
the accuracy of either type of judgment was related to learning style. Data
from both experiments suggested that frequency is encoded directly with the
memory representation for the concept. The second experiment revealed a sen-
sitivity for frequency of both higher and lower categories, although the
former were substantially underestimated. Learning style was not related to
either frequency judgment task. The observed underestimation of high fre-
quencies implies a need to take this fundamental judgment bias into account
when training persons to make frequency judgments as part of analytical tasks
such as risk assessment.

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Technical Report 653

An Investigation of Judgments of Category Frequency

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An important and challenging area of Army training is the training of cognitive skills necessary to effectively perform in a modern battlefield environment. The criticality of human judgment for analyzing threat situations, solving problems, and making decisions underscores the need to train Army personnel to be logical and effective thinkers. One approach to this challenge is to identify the cognitive skills needed to perform various tasks, evaluate how effectively people perform these skills, and then develop appropriate training programs.

A key element of this approach is the supportive role of research that investigates human cognitive capabilities and limitations. The research presented in this report contributes to our understanding of human capabilities in the area of frequency estimation, which is thought to be an important component of several processing activities such as judging the truthfulness of statements, assessing risk, and predicting future events. The current results have implications for how concept frequency is represented in memory and for factors that do and do not affect frequency judgment accuracy.

EDGAR M. JOHNSON
Technical Director

AN INVESTIGATION OF JUDGMENTS OF CATEGORY FREQUENCY

EXECUTIVE SUMMARY

Requirement:

The requirement was to investigate human processing capabilities, limitations, and individual differences in judging how often categories of items occur.

Procedure:

In two experiments, research participants observed instances of natural categories (e.g., countries, trees, units of time, etc.) and then provided absolute judgments of category size. In Experiment 1, the variability of individual category occurrences was manipulated to assess whether category size estimates were based on access of frequency stored directly with the concept in memory or from a mental count of individual instances. Experiment 2 evaluated subjects' capability to discriminate the frequencies of both lower level categories (e.g., states and countries) and higher level categories (e.g., places) and further examined the basis for frequency estimation by varying the number of seconds allowed per frequency judgment. The learning style of subjects was assessed to evaluate the relationship between this variable and accuracy of the frequency judgments.

Findings:

The data from both experiments suggested that frequency may be encoded directly with the memory representation for the concept. Experiment 2 results revealed sensitivity for the frequency of both higher and lower level categories, although the size of higher level categories was substantially underestimated. Learning style did not appear to be related to either type of frequency judgment.

Utilization of Findings:

The research findings provide background information in support of current efforts to describe and train cognitive skills needed to perform Army tasks. Memory for frequency information is thought to play a role in several human processing activities such as risk assessment and prediction of future events. An understanding of how well people judge the frequency of past events in the laboratory may allow us to anticipate level of performance in such tasks as estimating the frequency that the enemy reacts offensively in a particular combat situation or the frequency of repair required for optimal vehicle maintenance. The present finding that people underestimate the frequency of categories of events implies a need to take this judgment bias into account when training military soldiers and officers to make frequency judgments as part of complex analytical tasks.

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AN INVESTIGATION OF JUDGMENTS OF CATEGORY FREQUENCY

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An important challenge currently faced by the Army is that of training soldiers and officers to perform well on tasks that require a high level of cognitive functioning. Cognitively demanding tasks such as those involved in command and control, intelligence analysis, and decision making are difficult to train, since the underlying cognitive processes involved are not readily observed or even easily identified. However, some innovative applied research dealing with the description and analysis of cognitive processes needed to perform specific Army tasks has recently been done (Thompson, Hopf-Weichel, & Geiselman, 1984). This work is supported by earlier research efforts that take an in depth look at very specific cognitive capabilities. It is important, therefore, to continue research in this area. The purpose of this report is to describe such a research study. Specifically, the study examined people's judgments of concept frequency and individual differences in the ability to accurately make such judgments. The results were intended to provide information on how well people judge the frequency of classes of events and to improve our understanding of how concept frequency is represented in memory.

A substantial body of research indicates that people are sensitive to the frequency of events in their environment. For example, people are quite good at judging the relative frequency of occupations and of causes of death in their country (Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978). Judgments of how often specific words (Shapiro, 1969), letter pairs (Underwood, 1971), and individual letters (Attneave, 1953) appear in the English language correlate highly with actual frequency of occurrence. Moreover, in laboratory experiments assessing people's ability to report the situational frequency of stimulus events, the results have reflected fairly accurate judgments of both absolute and relative frequency (Hintzman, 1969;

Radtke, Jacoby, & Goedel, 1971; Underwood & Freund, 1970; Underwood, Zimmerman, & Freund, 1971).

This sensitivity to event frequency has been viewed as a critical component of many human processing activities such as single item recognition (Harris, Begg, & Mitterer, 1980), verbal discrimination learning (Underwood & Freund, 1970), probability matching and prediction of future events (Estes, 1976; Whitlow & Estes, 1979), concept acquisition (Kellogg, 1980), impression formation (Zajonc, 1968), risk assessment (Lichtenstein et al., 1978), and decisions about the truthfulness of statements (Bacon, 1979; Hasher, Goldstein, & Toppino, 1977). The apparent reliance on frequency for many cognitive tasks suggests a need to investigate the types of frequency information that people encode and the nature of such encodings.

While most research has focused on sensitivity to the frequency of explicitly presented individual items, data reported by Alba, Chromiak, Hasher, and Attig (1980) suggest that people are also sensitive to the frequency of categories of items and that they may automatically associate frequency with an implicitly referenced category name. In their experiments, subjects observed the names of instances of natural categories and then provided absolute judgments of category frequency. The judgments revealed an awareness of actual category frequency under incidental as well as intentional instruction conditions. Moreover, since the time allowed per frequency judgment did not reliably influence performance, they concluded that subjects were able to access the category frequency information directly from memory rather than derive it from a retrieval and count of individual instances.

One purpose of the present study was to further investigate whether category frequency is directly accessed or indirectly accessed via counting by

manipulating the variability of category instances. An experiment was designed in which a given category occurring N times involved either the presentation of N unique instances or fewer than N unique instances that were repeated. It has been suggested that item frequency judgments are based on a retrieval of multiple traces and that the retrieval of those traces may be facilitated to the extent that they are similar (Hintzman & Stern, 1978). If so, one might anticipate better performance in the repetition condition, since repetition of exemplars should lead to greater similarity of memory traces. On the other hand, if category frequency estimates are not derived through a retrieval of exemplars but rather are based on a readout of information stored directly with the category representation, one might expect category frequency estimates to be unaffected by the manipulation of exemplar variability. This would be the case if each presentation of a category exemplar led to implicit generation of the category name and to an associated increment in the category's frequency.

The latter expectation is supported by research suggesting that category membership is an integral part of a word's encoding. For example, Warren (1972) observed that color naming in a Stroop task was relatively slow when the test word was the category name for an earlier presented list of to-be-remembered words. His conclusion was that earlier presentation of the category instances may have primed the category name which, in turn, interfered with color naming. Using a relearning paradigm, Nelson, Fehling, and Moore-Glascock (1979) demonstrated that subordinate and superordinate information are part of the memory trace of an encoded word and that it may be the only type of semantic information saved in the trace of a forgotten item. This evidence suggests that the presentation of instances of natural categories leads to implicit reference to at least some superordinate

information.

What is less clear is whether item presentation leads to implicit reference to more than one superordinate and to a direct association of frequency with each referenced superordinate. In order to examine this issue, a second experiment was designed to examine whether people can accurately report both lower and higher order category frequency estimates. For example, following presentation of the names of states and countries, one could request absolute frequency judgments for the lower level categories, states and countries, or the higher level category, places. If frequency judgments for both higher and lower order categories can be made, one might also ask whether both levels of superordinate frequency are directly accessed or derived from a mental count of exemplars. This latter question was addressed in Experiment 2 by varying the time allowed per absolute superordinate frequency judgment (see also Alba et al., 1980). If superordinate frequency judgments were based on a retrieval and count of exemplars, subjects in a slow-paced test condition would presumably perform better. However, if the memory representation for the concept were directly tagged for frequency, the frequency information could be read out at test, and performance for the fast- and slow-paced groups would not differ.

Another issue which has received much attention in recent years is the "automatic" nature of frequency encoding. Hasher and Zacks (1979) have proposed that frequency is an attribute of an event's memory representation and that it is encoded automatically. Evidence in support of this view is that performance on tests of item frequency is nearly equivalent under incidental and intentional instructions (e.g., Flexser & Bower, 1975), does not reliably improve with practice (Hasher & Chromiak, 1977), and is independent of subject characteristics that are related to performance on

effortful processing tasks such as free recall (e.g., Attig & Hasher, 1980; Goldstein, Hasher, & Stein, 1983; Zacks, Hasher, & Sanft, 1982). However, Greene (1984) has recently reported that frequency test performance is related to intentionality to learn and has argued that the evidence for automatic frequency encoding for individual items is not strong. Much less is known about the processing of superordinate frequency information. Although Alba et al. (1980) have suggested that category frequency may be encoded into memory automatically, there is some evidence that subjects' preference for encoding a particular semantic memory attribute such as category membership may be influenced by only a small amount of training (Hinman & Freund, 1976).

It is plausible that encoding and subsequent retrieval of category frequency would be related to one's tendency to conceptually organize information when placed in a learning situation. To test this possibility in Experiment 2, the accuracy of judgments of superordinate frequency was correlated with learning style as measured by the Inventory of Learning Processes (ILP) developed by Schmeck, Ribich, and Ramanaiah (1977). The inventory's deep processing scale which has been shown to relate to one's attention to semantics (Ribich & Schmeck, 1979) and ability to build conceptual tree structures (Ribich, 1977) was expected to correlate with sensitivity to differences in higher level category frequency. The elaborative processing scale of the ILP which relates to tendency to subjectively organize recalled information (Ribich & Schmeck, 1979) was also predicted to be positively correlated. A third scale, fact retention, which purportedly measures attention to detail and specific pieces of information, was expected to be negatively correlated with task performance since attention to specifics may detract from attention to categorical relationships. Finally, the predicted relationships between frequency task performance and

the ILP scales were expected to be stronger for the higher level superordinate condition because of the greater organizational requirements.

To summarize, two experiments are being reported. The first addressed the basis for category frequency estimation by examining whether repetition of category instances influences category frequency judgments. If judgments of category size rely on a retrieval and count of exemplar traces, then repetition of exemplars should facilitate trace retrieval and result in more accurate judgments. However, judgments based on direct access of frequency information stored with the category name should be unaffected by instance variability. The second experiment was designed to investigate whether people can accurately report both higher and lower level superordinate frequencies and whether both types of frequency can be directly accessed. It was hypothesized that the accuracy of at least the higher order superordinate frequency judgments would be systematically related to learning style.

<center>Experiment 1</center>

Method

Subjects. Forty-eight students at Southern Illinois University at Carbondale served as subjects. Thirty-six were enrolled in undergraduate psychology courses and received course credit for their participation. The remainder were graduate student volunteers who were unfamiliar with the study.

Design. The experiment was a 4 (category frequency) X 3 (repetition condition) repeated measures design. The actual occurrence frequency of each category was 0, 4, 7, or 10. Repetition conditions were formed such that the number of unique exemplars within a category was 2, 3, or N, where N equalled the category frequency. The factorial combination of these two variables yielded a 12-cell matrix to which two categories were randomly assigned per cell. The category pairs were rotated through all 12 cells to ensure that

across subjects each category appeared in each experimental condition. This counterbalancing procedure resulted in 12 groups of 4 subjects each. Assigr ent of groups to conditions was random.

Materials. Twenty-four categories were selected from the Battig and Montague (1969) norms. For each category, the 10 most dominant instances were selected with the restriction that an item's category membership not be ambiguous. If an instance was judged to belong to more than one category, the next most dominant instance was selected. In addition, five noncritical categories were chosen from which 10 buffer items were drawn.

Two categories were randomly assigned to each of the 12 frequency by repetition conditions. The condition determined category composition as it would appear in the presentation list. Although 10 exemplars of each category were available, not all were needed for most conditions, and the selection of exemplars from this pool was random. For those conditions where exemplars were differentially repeated, assignment of exemplars to number of repetitions was also random.

The presentation list included 18 critical categories, two categories from each of the nine conditions having greater than zero frequency. (Categories with zero frequency were used only at test.) One category from each condition was randomly chosen to appear in the first half of the list; the other category appeared in the last list half. Assignment of category words to list position insured a lag of 5-9 words between same-category items but was otherwise random. The rotation of categories through conditions required the construction of 12 presentation lists. Each list contained 126 critical words plus 10 buffers for a total list length of 136 items.

Test materials consisted of four random orders of the names of the 24 critical categories. Twelve subjects were randomly assigned to each of the

four orders. At test subjects received a sheet of paper with 24 numbered
lines for recording their frequency judgments.

Procedure. Subjects were tested in groups of four or less. Initial
instructions (which can be seen in Appendix A) indicated that a list of words
would be presented on slides followed by a nonspecified test of memory. The
words were presented at a 3-second rate via a Kodak carousel projector and
timer. Immediately following list presentation, subjects were asked to give
an estimate of the number of times each of the 24 categories had appeared. As
part of the test instructions (see Appendix A), a short sample list was used
to insure that subjects understood that a judgment was to reflect the total
number of times a category had occurred, including all repetitions of
exemplars. The category names were projected one at a time for 5 seconds
each, and subjects recorded their estimates on the answer sheet.

Results

The dependent measure was absolute judgments of category frequency.
Subjects' two judgments per category condition were averaged, and the means
were submitted to a 3 x 4 repeated measures analysis of variance. The main
effect of actual category frequency was significant, F (3, 141) = 96.84, MSe =
15.42, p < .001. The Table 1 means show that category frequency judgments
increased as actual frequency increased from 0 to 10, and Tukey tests
revealed that all pairwise differences between means were significant (p <
.01). The number of unique exemplars did not affect frequency judgments nor
was there a significant interaction (both F's < 1.00). These data suggest
that subjects were able to discriminate the occurrence frequency of categories
and that judgments were unaffected by the variability of exemplars.

Inaccuracy scores were also derived by taking the unsigned difference
between actual category frequency and the absolute judgment. Subjects' two

Table 1

Experiment 1 Mean Judgments of Category Size as a Function of Number of Unique Instances and Actual Frequency.

| No. Unique Instances | Category Frequency | | | | Mean |
	0	4	7	1C	
2					
Mean	0.65	4.13	5.57	8.58	4.73
SD	1.08	2.70	3.50	6.65	
3					
Mean	0.64	4.14	5.58	7.72	4.52
SD	1.21	2.23	2.82	5.75	
N					
Mean	0.42	4.02	5.63	8.57	4.66
SD	0.85	2.39	3.07	5.02	
Mean	0.57	4.09	5.59	8.29	

Note. N equalled the actual category frequency.

inaccuracy scores per category condition were averaged, and a 3 x 4 repeated measures analysis of variance was performed on these data. The result was a significant main effect of actual category frequency, F (3, 141) = 54.44, MSe = 7.65, p < .001, such that judgments became less accurate as category frequency increased. Tukey tests to evaluate the differences between frequency levels showed that all differences in inaccuracy were significant, except between frequency levels 4 and 7. Inspection of the absolute judgments indicated that inaccuracy was due primarily to underestimation of higher actual frequencies.

Finally, discriminability scores were calculated to assess subjects' ability to discriminate category frequencies and to determine whether discriminability was affected by category composition. A commonly used measure of a subject's discriminability is the product-moment correlation between actual and judged frequencies (e.g., Alba et al., 1980; Flexser & Bower, 1975). A slightly different measure was adopted for use in the present analysis to take into account the variability of judged frequency values. For each subject, absolute judgments were regressed on actual frequencies, and the b-weight was taken as the subject's discriminability score. A b-weight of 1.0 indicated that the subject's differentiation of category frequency paralleled the actual differences in occurrence frequency of those categories. B-weights less than or greater than 1.0 respectively reflected low or high discrimination of category frequency, in comparison with the actual differences in category frequency. Three discriminability scores were obtained for each subject, one for each of the repetition conditions. The mean scores for conditions of 2, 3, and N unique exemplars were .77, .69, and .79, respectively, and these differences did not approach significance (F < 1.00). For all three conditions, most subjects' discriminability scores were

ess than 1.0, indicating that perceived category frequency differences were not as large as actual category frequency differences.

Discussion

The results were consistent with those reported by Alba et al. (1980) in suggesting that people are sensitive to the occurrence frequency of implicitly referenced categories. Following the presentation of category instances, subjects were able to report category frequency with a fair degree of accuracy even though this type of test was not expected. Sensitivity to the differential frequency of categories was reflected both in the effect of actual category frequency on absolute frequency judgments and in average discriminability scores which were positive and moderately high. In general, however, judged differences were not as large as actual differences in category frequency due mainly to the increasing underestimation of more frequent categories.

The goal of the experiment was to determine whether category frequency judgments are influenced by context variability as defined by the number of unique category instances. There is evidence to suggest that individual words presented in a stable encoding context are judged as more frequent than words presented in a variable encoding context (Hintzman & Stern, 1978; Rose, 1980; Rowe, 1973). In explaining the finding, Hintzman and Stern (1978) proposed that retrieval of multiple traces of the same word is facilitated if the traces are similar as a result of stable encoding. The same logic might be applied to the retrieval of traces representing category instances, and on this basis it was predicted that categories whose instances were repeated would receive high absolute frequency estimates relative to categories whose individual instances were different.

Since an effect of exemplar variability was not found, the results do not

support the hypothesis that category frequency judgments are based on a retrieval of the traces of individual instances. Instead, it appears that subjects were able to read out frequency information stored directly with the category representation. The data also indirectly suggest that, within a category, the category representation did not vary substantially across the different instances. That is, different exemplars brought to mind or activated the same category representation, even in the most variable condition. This seems plausible for two reasons. First, dominant exemplars were used, and second, once a category representation had been primed by one instance, its chances of being referenced again during presentation of another related instance should be higher.

Several findings in the literature are compatible with the interpretation that frequency information accrued to the category representations and that frequency judgments were based on direct access of that information. For example, the evidence that superordinate information is an integral part of a word's encoding (Nelson et al., 1979; Warren, 1972) is consistent with the current interpretation that frequency accrued directly to the superordinate representation as exemplars were presented. Also, Pitz (1976) observed category frequency estimates to be independent of memory for specific category instances. As mentioned earlier, Alba et al. (1980) proposed that superordinate frequency information is directly accessed, based on their finding that category frequency judgments were unaffected by test rate. The present data in conjunction with these previous finding suggest that there was implicit reference to the category as instances were presented, and that the category frequency was directly accessed at test.

The second experiment to be reported here continued to examine the basis for concept frequency judgments by including two levels of superordinate

frequency and by varying the test rate. Learning style was also assessed to determine its relationship to accuracy of category size judgments.

Experiment 2

Method

Subjects. The subjects were 80 students enrolled in undergraduate psychology courses at Southern Illinois University at Carbondale. They received either course credit or a $3 payment for serving in the experiment.

Design. Half of the subjects made judgments of lower level (LL) category frequency (e.g., the number of states or countries), and half made judgments of higher level (HL) category frequency (e.g., the number of places). Actual LL or HL category frequency was manipulated within subjects. The LL categories occurred 2, 4, 6, 9, 12, or 16 times. HL category frequencies were derived by combining pairs of LL frequencies (2 and 4; 4 and 6; 6 and 9; 9 and 12; 12 and 16). Thus the actual HL category frequencies were 6, 10, 15, 21, or 28. For both types of frequency judgment, test rate was varied such that half of the subjects had 3 seconds per judgment and half were allowed 10 seconds per judgment.

The two LL categories comprising a given HL category were treated as a pair. The five pairs of related LL categories were rotated through the HL frequency conditions such that each pair appeared once at each of the five HL presentation frequencies. This counterbalancing required that the 20 subjects in each judgment type by test rate group be randomly divided into 5 subgroups of 4 subjects each.

Materials. Five pairs of categories (states and countries; alcoholic beverages and nonalcoholic beverages; furniture and kitchen utensils; units of time and units of distance; trees and flowers) were selected from the Battig and Montague (1969) norms such that the members of each pair shared a common

higher order superordinate (Places, Beverages, Household Goods, Units of
Measure, and Plants, respectively). The common superordinate was judged to be
relevant only to the two categories of the pair and not to other categories
included in the list. For each of the 10 categories, the 16 most dominant
instances that were also unambiguous in category membership were selected and
formed the pool of category items from which the presentation lists would be
constructed. Each of the five category pairs was randomly assigned to a HL
category frequency; the individual pair members were then randomly assigned to
the LL frequencies within their HL frequency level. For each LL category, the
required number of exemplars was randomly selected from the 16 available,
except in the one case where all 16 category exemplars were to be presented.

In addition to the category words, 74 adjectives were used as buffer and
filler items. Five buffer words appeared at the beginning and at the end of
the presentation list. The assignment of category instances to list positions
was random with the restriction that words from the same HL category were
separated by 5-9 intervening items. Filler items were inserted as needed to
accommodate lag requirements. Total list length was 154 words, and all list
items were prepared on slides.

Test materials for half of the subjects consisted of 10 slides of the LL
category names. Materials for the other half of the subjects were 5 slides of
the HL category names. A test sheet with either 10 (LL category condition) or
5 (HL category condition) blank lines was given to subjects to record absolute
frequency judgments. Finally, copies of the Inventory of Learning Processes
(ILP) with written instructions and answer sheets were provided. The ILP
contains 72 true-false questions regarding learning style. A copy of this
inventory is provided in Appendix B.

Procedure. The basic procedure was the same as that in Experiment 1. At

the end of list presentation, subjects were informed that the memory test was
to recall the frequency of categories of instances. Subjects were given a
test sheet appropriate to their condition, and as the names of LL categories
or HL categories were presented, they recorded an absolute frequency estimate
for each. (Instructions used for study and test are given in Appendix A.)
The category names were presented at either a 3-second or 10-second rate. At
the end of the frequency test, $\underline{E}$ collected answer sheets and then gave
subjects the self-paced ILP with written instructions. The entire session
lasted about 45 minutes.

Results

LL Category Frequency Judgments. Subjects in the LL condition judged 2
categories each at frequency levels 4, 6, 9, and 12, and 1 category each at
frequency levels 2 and 16. Where 2 judgments were available, the 2 were
averaged to obtain a mean judgment for that frequency. The resulting data for
all 40 subjects were submitted to a 2 (test rate) by 6 (actual LL category
frequency) mixed analysis of variance.

The main effect of actual LL category frequency was significant, $\underline{F}$ (5,
190) = 26.45, MSe = 10.21, $\underline{p} < .001$. The means shown in Table 2 reveal that
absolute frequency judgments reflected actual increases in category
frequency. Tukey pairwise comparisons among the 6 marginal means indicated
that all differences between nonadjacent frequency levels were significant
($\underline{p}$'s < .01). With the exception of the least frequent category, subjects
tended to underestimate actual category frequencies. Neither test rate nor
the interaction approached significance ($\underline{p}$'s > .05).

Inaccuracy scores were calculated as in Experiment 1 by taking the
absolute difference between actual and judged category frequency. As
explained above in the presentation of absolute judgments, averaging of the 2

Table 2

Experiment 2 Mean Judgments of Lower Level Superordinate Frequency as a
Function of Actual Frequency and Test Rate.

	Actual Frequency						
Test Rate	2	4	6	9	12	16	Mean
3 Sec							
Mean	3.45	3.73	4.98	7.83	8.05	10.75	6.46
SD	3.44	2.41	3.29	7.10	5.39	7.93	
10 Sec							
Mean	2.25	3.48	5.83	5.93	7.95	8.45	5.65
SD	2.15	2.53	3.61	2.97	3.84	4.42	
Mean	2.85	3.60	5.40	6.88	8.00	9.60	

scores at frequency levels 4, 6, 9, and 12 was performed. Each subject
contributed 6 inaccuracy scores which were submitted to a 2 (test rate) by 6
(category frequency) mixed analysis of variance. The effect of actual LL
category frequency was again statistically reliable, F (5, 190) = 31.36, MSe =
7.49, p < .001. In general, the more often a category had occurred, the more
inaccurate was the average frequency judgment for that category. Increasing
inaccuracy was again primarily attributable to increasing underestimation as
actual frequency increased. The inaccuracy scores for fast- and slow-paced
subjects were not reliably different, nor did frequency interact with test
rate (p's > .05).

As in Experiment 1, a discriminability coefficient was calculated for
each subject by regressing absolute category frequency judgments on actual
category frequencies. The mean and standard deviation of the discriminability
scores for the group was .50 and .31, respectively. Only four subjects had
scores equal to or greater than 1.0. The finding that scores were generally
less than 1.0 indicated lower discrimination of category frequency in
comparison with the actual differences in category frequency. A comparison of
average scores for subjects in the fast and slow test rate conditions
indicated that the difference (.55 versus .45) was not statistically reliable,
p > .05.

HL Category Frequency Judgments. A 2 (test rate) by 5 (actual
frequency level) mixed analysis of variance performed on subjects' absolute
frequency judgments revealed a significant main effect of actual HL category
frequency, F (4,152) = 16.25, MSe = 27.85, p < .001. The means in Table 3
show that frequency judgments increased with increasing actual category
size. The results of Tukey analyses indicated that the average judgment for
the category that had occurred 28 times was significantly higher than the

Table 3

Experiment 2 Mean Judgments of Higher Level Superordinate Frequency as a

Function of Actual Frequency and Test Rate.

	Actual Frequency					
Test Rate	6	10	15	21	28	Mean
3 Sec						
Mean	6.80	8.70	8.50	10.95	15.95	10.18
SD	5.44	6.46	5.17	8.24	11.05	
10 Sec						
Mean	4.90	6.35	6.95	10.10	12.90	8.24
SD	3.55	5.38	3.43	12.04	8.59	
Mean	5.85	7.53	7.73	10.53	14.43	

average judgment for categories that had occurred 6, 10, or 15 times; mean judgments for categories occurring 6 and 21 times were also significantly different. Subjects tested at the faster pace tended to give higher frequency estimates than slower paced subjects. The effect of test rate was not statistically significant, however, nor was there a frequency by test rate interaction (both p's > .05).

An identical analysis performed on subjects' inaccuracy scores revealed that the only significant effect was again that of actual frequency, F (4,152) = 45.14, MSe = 21.62, p <.001. The more frequently the HL category had appeared during study, the more inaccurate was its average frequency judgment. This pattern was consistent for subjects in both test rate conditions and reflects an increasing degree of underestimation as actual frequency increased. Tukey pairwise comparisons of the five marginal means indicated that differences between mean inaccuracy scores were statistically significant except for comparisons between frequency levels 6 and 10; 10 and 15; and 21 and 28.

The mean discriminability coefficient for subjects in this condition was .37, and the standard deviation was .31. The magnitude of these scores indicated that discrimination of HL category frequency was low relative to the actual differences in frequency. The amount of time to make the frequency judgments had no reliable effect on frequency discriminability (p > .05).

Combined Discriminab ity Scores. The discriminability scores for all 80 subjects were entered into a 2 (type of judgment) by 2 (test rate) between-subjects analysis of variance to assess whether these variables had any effect on frequency discrimination. Although subjects in the LL category group tended to show better frequency discrimination (Mean = .50) than subjects in the superordinate group (Mean = .37), this difference was not statistically

reliable, and no other effects were significant (all p's > .05).

ILP Data. The ILP data included all subjects' scores on the deep
processing, elaborative processing, and fact retention scales. An overall
mean inaccuracy score was calculated for subjects by averaging their six LL or
five HL category frequency inaccuracy scores to allow an examination of the
relationship between mean inaccuracy of frequency judgment and scores on the
ILP scales. An average Pearson product-moment correlation between inaccuracy
and each of the three scales was calculated for both judgment groups. Results
or t-tests indicated that none of these correlations (the highest of which was
-.30) was significantly different from 0 (p's > .05). The inaccuracy scores
of subjects who made HL judgments were more highly correlated with all three
ILP scales than were the inaccuracy scores of subjects in the LL judgment
condition, although the differences were not significant (all p's > .05). The
correlations suggested that learning style was not related to performance on
either type of frequency judgment task.

Individual Differences. Finally, an analysis was performed to compare
the two judgment groups on the extent to which individuals differed in their
absolute frequency judgments. For each group, a measure of individual
differences was calculated by subtracting the within-subject error variance
from the between-subject error variance. A quasi-F ratio of the HL group
measure to the LL group measure was formed, and appropriate degrees of freedom
were calculated (Kirk, 1968, p. 213). The obtained F value was statistically
significant, F (51,50) = 2.44, p < .01, indicating larger individual
differences among subjects making HL category frequency judgments compared to
subjects making LL judgments.

Discussion

The LL category frequency judgment data confirmed the Experiment 1

results and the earlier Alba et al. (1980) finding that persons are sensitive to the occurrence frequency of categories of information. Subjects' ordering of categories by absolute frequency was consisten: with actual presentation frequency, and discrimination of frequency differences was reasonably good. Discriminability coefficients were not as high as in Experiment 1, which likely was due to the higher actual category frequencies in Experiment 2. Absolute frequency judgments again reflected increasing underestimation as category size increased.

Of greater interest were the HL judgment data which suggest an awareness of frequency for higher order superordinates that may also be implicitly referenced. Sensitivity to HL category frequencies was indicated by the absolute frequency judgments and by moderate discriminability coefficients. Subjects generally underestimated the frequency of HL categories and, consistent with the LL category frequency judgment data, degree of underestimation increased with increases in actual frequency. The lower accuracy and the poorer differentiation observed for the HL judgment group relative to the LL judgment group appear due to the higher actual frequency (and thus greater underestimation) of the HL categories. This general phenomenon of underestimation will be treated more thoroughly in the general discussion.

For both judgment groups, no performance differences between subjects in the fast and slow test conditions were found in absolute estimates, accuracy, or differentiation. A similar result has been reported by Alba et al. (1980) in their investigation of lower level category frequency judgments. The present findings suggest that frequency information is attached to the memory representation for both higher and lower order superordinates as the instances are presented, and that at test such information can be directly accessed. If

subjects needed to derive their estimates from a retrieval and count of presented instances, one would expect task performance to benefit from additional time. Of course it is possible that a retrieval and count of presented instances did occur at test and that even a very few seconds was sufficient to derive the estimate. Compared to the former interpretation, however, such an explanation seems intuitively less likely.

The ILP data provide some information concerning the relationship between learning style and superordinate frequency estimation. The expectation was for relatively good performance by high scorers on deep and elaborative processing and relatively poor performance by high scorers on fact retention, particularly for the group that judged HL superordinate frequency. Since none of the scales correlated significantly with frequency task performance, learning style does not appear to be related to ability to judge superordinate frequency. The individual differences data revealed that differences were especially large on judgments of the HL superordinate frequency. Tendency to organize as measured by the ILP scales, however, does not account for those individual differences. It may be the case that performance on this task is not dependent on any strategy, or that given the length of the list, an organizational or counting strategy was simply too difficult for subjects to employ.

General Discussion

The data support the hypothesis that people are sensitive to the occurrence frequency of categories of items as well as to the frequency of explicitly presented individual items. In extending the Alba et al. (1980) findings regarding category frequency sensitivity, the present study suggests that people are aware of the presentation frequency of more than one level of superordinate.

In both experiments, subjects tended to underestimate actual frequencies and to show increasing underestimation as actual frequency increased. A complementary finding in the item frequency literature is that people generally overestimate low frequencies of about three or less and underestimate frequencies greater than three (e.g., Begg, 1974; Hintzman, 1969). In the present study, the pattern of underestimation was especially pronounced. Moving from lower to higher levels of categories, the degree of underestimation substantially increased as did actual frequency levels. The differences in accuracy and differentiation that were observed between the two types of judgments may be largely attributable to the differences in actual frequency and the associated underestimation.

The basis of the observed underestimation apparently is not due to anchoring on an average frequency, in which case one would expect to see fairly symmetrical over- and underestimation around the mean. Also, in the HL condition of Experiment 2, subjects underestimated every frequency level. It is noteworthy that subjects also underestimate large values in judgments of numerosity for briefly presented arrays of stimulus elements (Mandler & Shebo, 1982) and in judgments of distance (Gibson & Bergman, 1954). The tendency across tasks to underestimate large numbers suggests the involvement of a rather fundamental judgment bias.

The study's more interesting findings are those that reveal how higher and lower level category frequency may be encoded into memory. The data from both experiments suggest there is direct encoding of frequency with the superordinate representations which makes possible a direct access of category frequency at test. That is, absolute category frequency judgments were not enhanced by the similarity of category instances as one might expect if a retrieval of individual traces was occurring. Moreover, the amount of time to

report an estimate had no effect on either level of superordinate frequency
judgment. The data from the two experiments together argue for a direct
readout of frequency information associated with the category representation
rather than for a retrieval and count of exemplars. Finally, although there
were large individual differences in task performance, particularly with
higher level superordinate frequency judgments, performance on this task does
not appear to be related to a learning style that emphasizes conceptual
organization.

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Appendix A

Appendix A contains copies of the study and test instructions

that were read to subjects in Experiments 1 and 2.

Instructions to Subjects

Experiment 1

Study instructions. The purpose of this experiment is to investigate people's memory for events in their environment. There are two parts to the experiment.

For the first part, you will see a series of familiar English words projected on the wall ahead of you. The words are printed in capital letters and will be shown one at a time for 3 seconds each. some of the words will be repeated. The total list length is 136 words, and due to the length of the list, it will be necessary for me to change slide trays about halfway through.

After all words have been shown, Part 2 of the experiment will be a memory test for the words. I will give you more specific instructions about the memory test when we get to Part 2. Do you have any questions so far?

Test instructions. For the second part of the experiment, I am asking you to remember how often you saw a particular category of words. That is, the words you saw can be grouped into familiar classes or categories. I will project the name of a category, and your task is to write down an estimate of the total number of times the category occurred.

Let me illustrate with a brief example:

> LAWYER
>
> SAPPHIRE
>
> DENTIST
>
> DIAMOND
>
> RUBY
>
> DENTIST
>
> EMERALD

Here there are two categories, precious stones and occupations. The category

precious stones appeared four times in the list, while the category

occupations occurred three times. It doesn't matter that "dentist" was

repeated; the correct answer is three.

On your answer sheet are 24 blanks, one for each category estimate. When

a category name is shown, you will have 5 seconds to write down your best

estimate of how often that category occurred. If you don't think you saw any

instances of that category, write "0". Please give your best answer to each

category.

Experiment 2

Study instructions. The purpose of this experiment is to investigate

people's memory for events in their environment. There are three parts to the

experiment.

For the first part, you will see a series of familiar English words

projected on the wall ahead of you. The words are printed in capital letters,

and they will be shown one at a time for 3 seconds each. There are 154 words

in all. Because of the length of the list, it will be necessary for me to

make a slide try change partway through the list.

After all words have been shown, Part 2 of the expeiment will be a memory

test for the words. I will give you more specific instructions about the

memory test when we get to Part 2.

Frequency test instructions. Part 2 is a kind of memory test for the

words you just saw. For this part, I am asking you to think of the number of

times you saw an instance of a particular category. You may have noticed that

some of the words could be grouped into familiar classes or categories. I

will show the names of 7 (10) general categories. Your task is to write down

the number of times you think you saw a word that belonged to that category.

This task is timed. You will have 3 (10) sseconds to write our answer

for each category. Please give a number estimate for each category, even if you are unsure of your answer. Do you have any questions?

Appendix B

This appendix contains a copy of the <u>Inventory of Learning Processes</u> (Schmeck, Ribich, & Ramanaiah, 1977) administered in Experiment 2. The instructions to subjects are also included.

Instructions

This questionnaire asks you to describe the way you study and learn. There are many differnt ways to study and learn, any of which may be effective for a particular individual. Since this is the case, there are no "right" or "wrong" answers to these questions. We are simply trying to find out the ways in which people learn best.

Answer TRUE or FALSE to each statement in the survey booklet. Indicate your answers on the separate answer sheet. If a particular statement applies to you, circle T for TRUE. If a particular statement does not apply to you, circle F for FALSE.

In answering each question, try to think in terms of how you go about learning in general, rather than thinking of a specific course or subject area. Be accurate and honest in your answers. Be sure to complete all the items, but do not spend a great deal of time on any one of them. This survey is for research use only, and all information is kept confidential.

1. When studying for an exam, I prepare a list of probable questions and answers.

2. I have trouble making inferences.

3. In general, I think most textbooks are easy to read.

4. I increase my vocabulary by building lists of new terms.

5. I am very good at learning formulas, names, and dates.

6. New concepts rarely make me think of many other similar concepts.

7. Even when I feel that I've learned the material, I continue to study it.

8. I have trouble organizing the information that I remember.

9. Even when I know I have carefully learned the material, I have trouble remembering it for an exam.

10.. When taking notes, I write down all ideas regardless of whether I think that they're important.

11. I make simple charts and diagrams to help me remember material.

12.. I rarely write an outline of the material I read.

13. I do not try to convert facts in "rules of thumb."

14. I do well on tests requiring definitions.

15. I have a lousy memory for "trivia."

16. I usually refer to several sources in order to understand a concept.

17. I try to resolve conflicts between the information obtained from different sources.

18. I learn new words or ideas by visualizing a situation in which they occur.

19. I spend less time studying than most of my friends.

20. I learn new concepts by expressing them in my own words.

21. I often memorize material that I don't understand.

22. For exams, I memorize the material as given in the text or class notes.

23. I carefully complete all course assignments.

24. I have difficulty planning work when confronted with a complex task.

25. I "debate" with the material as I study it.

26. I remember new words and ideas by associating them with words and ideas I already know.

27. I review course material periodically during the quarter.

28. I often have difficulty finding the right words for expressing y ideas.

29. Toward the end of a course, I prepare an overview of all material covered.

30. I can easily handle questions requiring comparison of different concepts.

31. I rarely read beyond what is assigned in class.

32. I have difficulty learning how to study for a course.

33. I rarely sit and think about a unit of material which I have just read.

34. For me, note taking interferes with comprehension so I take few notes and listen more.

35. I have a regular place to study.

36. I read critically.

37. I "daydream" about thinks I've studied.

38. I do poorly on completion items.

39. I rarely use a dictionary.

40. I can usually establish the meaning of an unfamiliar word from the context in which it is presented.

41. I learn new ideas by relating them to similar ideas.

42. When learning a unit of material, I usually summarize it in my own words.

43. I maintain a daily schedule of study hors.

44. I think fast.

45. While learning new concepts their practical applications don't usually

come to mind.

46. I get good grades on term papers.

47. I'd rather read about a concept than talk about it.

48. Getting myself to begin studying is usually difficult.

49. I have difficulty locating particular passages in a textbook when necessary.

50. I can usually formulate a good guess even when I don't know the answer.

51. I have trouble remembering definitions.

52. I would rather read a summary of an article than the original article.

53. While studying, I attempt to find answers to questions I have in mind.

54. I can usually state the underlying message of films and readings.

55. I do not usually work through practice exercises and sample problems.

56. I find it difficult to handle questions requiring critical evaluation.

57. When I rehearse something, I usually just repeat it over and over to myself.

58. I have regular weekly review periods.

59. I do well on exams requiring much factual information.

60. Most of my instructors lecture too fast.

61. I rarely look for reasons behind the facts.

62. I cram for exams.

63. I need a summary statement at the end of a lecture.

64. When I study something, I devise a system for recalling it later.

65. I have trouble seeing the difference between apparently similar ideas.

66. I always make a special effort to get all the details.

67. I prepare a set of notes integrating the information from all sources in a course.

68. My memory is actually pretty poor.

69. I am rarely able to design procedures for solving problems.

70. I do well on essay tests.

71. I rarely use the library.

72. I need teachers who give a lot of examples.