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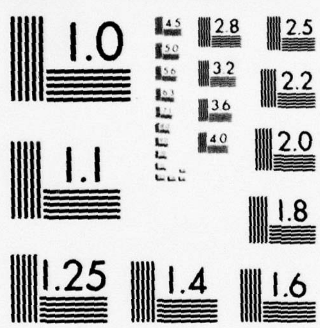

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An Information Processing Approach to Performance Assessment:

II. An Investigation of Encoding and Retrieval Processes in Memory.

Kathleen Fernandes
Andrew M. Rose

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This paper describes the tasks, methodology, and results of the second experiment carried out during a research program dealing with the development and validation of a comprehensive test battery which could be used as a research or performance assessment instrument. The focus in this case was on structural features of the information processing system, those that describe the nature of the information at a particular processing stage rather than the operations being performed. The six tasks in this experiment were concerned with the nature of memory

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representation and provided measures of various aspects of encoding and retrieving of previously stored information. The tasks selected for testing were chosen from among the various recognition-type and recall-type tasks presented by Underwood, Boruch, and Malmi (1977).

The major purpose of the present experimental study was to determine properties of the tasks selected for inclusion in the test battery. Specifically, the issues of the replicability of previous findings, the logistic feasibility of our adaptations, and the adequacy of the tests to provide measures of individual differences were addressed.

The tasks investigated included:

- Free recall (control, concrete, and abstract)
- Running recognition
- Interference susceptibility
- List differentiation
- Situational frequency
- Memory span

Several aspects of the results were evaluated for the final selection of measures to incorporate into the test battery. Consideration of the replicability of previous findings, Day 1 - Day 2 reliabilities, practice, intratask correlations, and the patterns of intertask correlations led to the summary judgments for the inclusion of a relatively small number of variables.

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INTRODUCTION

One approach to the problems of individual differences and performance assessment in personnel management draws upon the theoretical framework of human information processing. This approach focuses on the cognitive operations assumed or demonstrated to underlie human performance. Other approaches to the assessment of individual differences start with a specific criterion performance in a real-world situation, then develop an instrument that is successful in predicting actual performance. Because an information processing approach looks at fundamental parameters of behavior rather than actual job requirements, it can be used to understand as well as measure individual differences. In addition, an information processing approach provides the potential for building an assessment instrument that is applicable to a wide range of criterion tasks.

This approach was used by Rose (1974) in the development of the Information Processing Performance Battery (IPPB). The basic strategy employed in that research was to select experimental tasks from the psychological literature that had been demonstrated to be valid measures of information processing constructs. Rose selected nine tasks and administered them to large groups of subjects. Extensive correlational analyses were conducted to determine the degree of relationship among the various tasks and the reliabilities of each. These procedures resulted in identification of a set of tasks which were highly reliable, statistically independent, and construct valid, and which could be used in assessing individual differences in a wide variety of information processing skills.

This work has been extended in a current ONR-sponsored research program being conducted at the American Institutes for Research. The basic objective is to further develop and validate the IPPB so that eventually it can be used as an assessment device for the evaluation of performance in a wide variety of situations. The battery will be designed to possess high reliability and predictive validity for a wide variety of criterion tasks. The battery will also include tests that possess construct validity: there will be a firm theoretical and empirical basis for inferring the information processing structures and functions that the tests purport to measure.

The activities contained in the current phase of the research program are structured around a set of laboratory experiments. Each experiment addresses a different domain of cognitive processes as represented by several carefully selected information processing tasks. The tasks are identified primarily through an extensive review of texts, articles, and abstracts. Each task is evaluated on the basis of its logistic feasibility, reliability, and to a limited degree its construct validity. Pilot studies are conducted to determine the efficiency of methodological refinements of the selected tasks. The primary questions addressed in the experimental studies concern the replicability of previous findings, the construct validity of the tasks, and their adequacy in providing measures of individual differences.

The first experiment (Rose & Fernandes, 1977) consisted of eight tasks selected from the literature on memory, psycholinguistics, and visual information processing. These were areas in which a large body of research had accumulated since the IPPB was developed. The focus of the experiment was on tasks that measured functional rather than structural components of human information processing. The response measures for each task were interpreted as indicators of processing rates and time durations of stages. In order to delimit the scope of the tasks, a post hoc organizational structure consisting of cognitive operations was developed. All of the tasks were specified by some combination of operations. The adequacy of the specifications was evaluated by comparing the pattern of hypothetical operation descriptions with the observed responses.

This paper describes the tasks, methodology, and results of the second experiment carried out during this research effort. This experiment was designed to investigate other types of information processing activities that might be included as part of the IPPB. The focus in this case was on structural features of the information processing system, those that describe the nature of the information at a particular processing stage rather than the operations being performed. The six tasks in this experiment were concerned with the nature of memory representation and provided measures of various aspects of encoding and retrieval of previously stored information. This second experiment was more limited in scope than the first study, focusing more on the logistics of administering and scoring the tasks than on reliability and validity issues.

The tasks selected for pilot testing were chosen from among the various recognition-type and recall-type tasks presented by Underwood, Boruch, and Malmi (1977). In their study, it was assumed that when subjects were presented with a number of words to learn, they would abstract certain kinds of information about each word and perhaps about its relationships with other words in the task. The different types of information about words that get stored were called "attributes", and different tasks were selected in order to determine the interrelationships among memory attributes. Some of the attributes focused upon properties of the stored representation, while others were concerned with how a new chunk of information is integrated into previous knowledge. Underwood et al. included performance measures associated with different tasks in a factor analysis to determine if the attributes would form factors. They found that the factors that emerged were closely tied to tasks rather than attributes. The authors felt that individual differences in performance and response patterns on some of the tasks were so strong as to override any effect that variations in attributes might be having on memory.

Our approach is to capitalize upon and extend this previous work by exploring these tasks as potential measures of individual differences that could be included in a test battery. "Promising" tasks are adapted and administered to a group of subjects. If the results indicate that, where applicable, the major group effects are replicated in each paradigm, various task parameters are identified and analyzed.

The value of the paradigms for an assessment battery depends primarily on the measures derived from them and the properties of these measures when considered as potential individual difference variables. This distinction between task effects and measurement properties is particularly important in the present context since most of the paradigms were not originally generated for the study of individual differences; the scientists were primarily concerned with uncovering different aspects of the composition of the human memory system. Similarly, most of these paradigms have not previously been considered as tests per se; no thought has been given to typical test development issues. The distinction between group effects and individual measures is critical in that several theoretically independent measures can be obtained from each task. For example, the Shepard and Teghtsoonian task results can be described by a number of different parameters: the "standard" measure of proportion of correct items (or, more finely, proportion of "hits" and "false alarms"), the two parameters of the exponential equation that is the best fit to the probability-correct-by-lag function, and the signal-detection-theory parameters d' and β.

Another important consideration in the selection of individual difference variables is the susceptibility and sensitivity of each to strategies employed by the subjects. Unless we "know" what subjects are doing, several variables could be interpreted as reflecting alternative processes. In other words, it would be difficult to generate hypotheses concerning underlying determinants of performance -- the "construct validity" -- for operations or structures involved in each task. Selection of variables must also be constrained by the analyses that will be conducted using those variables. It does not suffice to say that an intratask and intertask correlation matrix will be generated in order to examine the relationships among the variables; the purpose for such an examination must be specified. In the previous study in this series (Rose and Fernandes, op. cit.), we were able (at least provisionally) to hypothesize the underlying operations involved for each variable entered into the correlation matrix. Thus, the pattern of obtained correlations was in a sense a test of several hypotheses. Furthermore, since all of our variables were measured along a time scale, relatively unambiguous interpretations of the correlations could be made. In the present context, however, due to the nature of the tasks and the obtained measures, it simply is not possible to identify unique operations associated with the tasks. In many cases, it is a matter of either: a) whether or not a subject did a particular operation or transform (e.g., whether or not a subject encoded words visually), or b) if a subject did perform an operation, how well it was performed (e.g., if a subject stored temporal information in the list differentiation task, how accurately it was stored).

It must be conceded that some of the above considerations and the judgments regarding inclusion or exclusion of variables are a function of the particular purposes and perspectives of the authors. That is, although a paradigm might be "good" in the sense of producing theoretically important phenomena, we might judge it to be inappropriate for the generation of measures of human information processing to be included in a test battery. Ideally, we would like each measure to be identified with a single cognitive process (or a definable set of processes, each of which is potentially isolatable via converging operations). Thus, we have shied away from variables which are difficult to interpret in terms of our existing set of constructs.

The next sections provide a detailed description of the conduct of the second experiment. First, the general method is described. This presentation is followed by a section on each of the tasks, including task description, procedure and stimuli, data analysis, and results.

General Method

The experiment was carried out on AIR premises, using 22 volunteer staff members as subjects. These subjects were unfamiliar with the tasks and procedures. A large conference room was arranged to accommodate the experiment. A projector controlled by a peripheral timer was used to present slides containing the stimuli. The timer could be set for inter-stimulus intervals ranging from 500 to 4000 msec. No more than eight subjects were tested at any one time; seating was arranged to minimize variability of viewing distance and angle from the screen. Subjects were provided with instruction booklets and response sheets for each task. Subjects participated in two testing sessions, two hours in length and scheduled two days apart. All of the tasks were presented in each session, in the same order.

At the beginning of each task, the experimenter read the instructions and answered questions. The beginning and end of each stimulus set were cued both orally by the experimenter and visually with a special slide on the screen. Durations of stimulus presentation and response generation were fixed, but adequate time was allowed for all subjects to view the stimuli and record answers.

TASK DESCRIPTIONS AND RESULTS

The six tasks studied in this experiment were: free recall (control, concrete, and abstract), running recognition, interference susceptibility, list differentiation, situational frequency, and memory span. Descriptions of each of these tasks follow below.

Free Recall

Task description. In the Underwood et al. study, free recall was tested under a variety of conditions using lists of words that were interrelated in certain ways. A control condition was included to provide a basis for comparison with the concrete and abstract conditions. This control condition was selected in the present study as a measure of short-term memory capacity. Underwood et al.'s condition comparing recall of concrete and abstract words provided a measure of encoding by imagery. The difference in recall for concrete and abstract words was used as an indicator of individual differences in subjects' propensity toward concrete memory representations as the form generally used in short-term memory.

In the control condition, Underwood gave subjects four successive lists of 24 words each, presented for a single study and test trial. The words were common five-letter words taken from the Thorndike-Lorge tables. The number of words correctly recalled was the primary dependent measure. Typically, performance improved with practice. Serial position curves for each list and for the four lists combined were found to be quite symmetrical, indicating that primacy and recency effects were essentially equivalent.

For the concrete-abstract condition, Underwood et al. constructed two 24-item lists of concrete words and two corresponding lists of abstract words, all of the lists matched for Thorndike-Lorge frequency. Testing was carried out under the same procedure used in the control condition. Recall on the concrete lists was substantially better than recall on the abstract lists; furthermore, there appeared to be consistent individual differences in performance among subjects.

Procedure. Subjects were shown 20 words at a rate of one word every 2 seconds. This presentation rate, which was faster than the 4-second rate used by Underwood et al., was used to reduce the opportunity for rehearsal between items. After presentation of a stimulus list, subjects were given one minute to write down, in any order, all of the words that they could remember. This procedure was followed in both control and concrete-abstract conditions. Below are the events in a typical trial:

Subject shown word list	Subject responds
sense	trust
medal	medal
steed	steed
.	
.	
.	
trust	

Stimuli and design. Underwood et al.'s materials for the two conditions were used in the first testing session, but the lists were cut from 24 to 20 words. The extra words from the control lists were compiled into 2 eight-item practice lists, one for each of the testing sessions. Additional word lists for the two conditions were generated in the following manner: A table of random numbers was used to identify page numbers within the Thorndike-Lorge tables from which to make selections. Words meeting the constraints in each condition were chosen randomly from among the words on these pages. The lists generated in this manner were quite similar in average Thorndike-Lorge frequency to the lists developed by Underwood et al.

Subjects completed one practice list, followed by four lists of control words, two lists of concrete words, and two lists of abstract words. The same list order was used in both testing sessions.

Data analysis. The dependent measure was the proportion of words correctly recalled on each list. These data were used to calculate an overall mean for each of the three conditions.

Results. Table 1 summarizes the results for the three conditions. The mean proportion correct in the control condition was .36 on Day 1 and .38 on Day 2 testing. This translates to about 7 or 8 words recalled from a 20-word list, and is consistent with other research indicating short-term memory capacity to be 7 $\pm$ 2 items for information presented in various modalities.

Mean proportion correct for concrete words was .43 for both testing sessions; for abstract words, the proportions were .34 and .37, respectively. When shown lists of concrete words, subjects were able to recall an additional one or two words per list compared to their performance on lists of abstract words. Although the improvement in recall was small, it suggests that subjects tend to use concrete rather than abstract representations in short-term memory.

Test-retest reliabilities were .79, .79, and .72 for the control, concrete, and abstract conditions, respectively, indicating that performance on the task was consistent from one session to the next for all three conditions. All of the measures showed nonsignificant practice effects. As a group, subjects improved only slightly from one testing session to the next on the control and abstract lists; performance on the concrete lists was the same on both days.

Although the pattern of Underwood et al.'s results was replicated in the current experiment, overall performance levels were consistently lower than those observed by Underwood et al. In their study, mean recall for control, concrete, and abstract lists was 12, 15, and 11 words, respectively. The lower recall scores in the present experiment can be attributed to differences in the educational backgrounds of the subjects tested and to procedural modifications, the most significant of which involved the presentation sequence for the three conditions. Where Underwood et al. administered the control lists and the concrete and abstract lists on different days, the current experiment

Table 1

Descriptive Measures for the Free Recall Task

Variable		N	Mean	Std. Dev.	Min.	Max.	Rel.	t-Value Day 1 vs 2
Proportion Correct - Control	Day 1	22	.36	.08	.23	.52	.79**	.83
	Day 2	22	.38	.13	.20	.70		
Proportion Correct - Concrete	Day 1	22	.425	.12	.25	.65	.79**	.44
	Day 2	22	.433	.13	.18	.67		
Proportion Correct - Abstract	Day 1	22	.34	.13	.18	.68	.72**	1.58
	Day 2	22	.37	.10	.20	.55		

** $p < .01$

presented the three list types in both testing sessions, in the same order each session. Practice on earlier lists may have improved recall on the abstract lists, hence reducing the magnitude of the differences between concrete and abstract words in the present study. Underwood et al.'s presentation rate was also longer, perhaps enabling the subjects to rehearse the words more thoroughly.

Running Recognition

Task description. Underwood et al. used a variation of the paradigm developed by Shepard and Teghtsoonian (1961) to measure certain aspects of memory search and identification. In the original task, subjects were presented with a lengthy list of three-digit numbers and were asked to identify each number as "old" (i.e., previously presented) or "new". The lists were constructed so that the intralist intervals between the original and test presentations of items varied. A retention function for a single item was inferred by plotting probability of recognition as a function of test lag. In addition, estimates of several signal detection parameters were generated for each subject. In the Underwood et al. study, the stimulus items were words rather than numbers, and the lists were constructed to evaluate the importance of the acoustic attribute in memory for words. The pattern of hits, misses, and false alarms obtained by Underwood et al. did not support their hypotheses about this attribute.

The Shepard and Teghtsoonian paradigm was one of the tasks included in the first AIR experiment (Rose & Fernandes, 1977). The paradigm was selected for that study because it provided a measure of memory capacity when the possibility of rehearsal is minimized and the interference of preceding material is maximized. The results obtained from the paradigm paralleled those of Shepard and Teghtsoonian. The adaptation of the task by Underwood et al. was of interest in the present study because it provided an opportunity to determine if a change in stimulus mode would provide results similar to the pattern obtained in the first AIR experiment.

Procedure. In this task, subjects decided whether or not they remembered having seen each word earlier in the series. If they had seen the word previously in the list, they were to respond "old"; if they had not seen the word before, they were to respond "new". Subjects had 3 seconds in which to make their judgment and to respond before the next word appeared. Below are the events in a typical trial:

Subject views word	Subject responds
mail	"new"
shone	"new"
.	.
.	.
.	.
mail	"old"

Stimuli and design. Underwood et al.'s lists were used to identify two sets of 51 words which appeared in two lists in the present experiment. The stimulus series developed by Rose and Fernandes (1977) was used to determine the word order in each list. Each number in the series was replaced by one of the words. Thus, the word lists in the current study possessed the same characteristics as the number lists in the earlier study. The lists were 101 words in length. With a single exception, every word in a given list appeared exactly twice. The second presentations of the words were placed so that several lags between first occurrence and subsequent test were represented. The lags used were 1, 2, 4, 8, 12, 16, 20, 24, 30, and 36 items, with five exemplars of each lag in a given list. Two lists were created, one for each testing session.

Data analysis. Two types of measures were used: "traditional" retention parameters and parameters derived from signal detection theory. Of the traditional measures, the two employed here were proportion correct (i.e., x/101) and a two-parameter estimate of the best-fitting curve for the probability-correct-by-lag function. This function was characterized by the least squares estimate for A and B in the equation:

$$y = Ax^B, \text{ where } A = \text{intercept and } B = \text{exponent.}$$

These parameters were calculated for each subject for each testing session.

The signal detection parameters were derived from two observed scores, namely:

(a) the probability that the subject responded "old" when the stimulus was old [p("O"/O)], or "hits"; and

(b) the probability that the subject responded "old" when the stimulus was new [p("O"/N)], or "false alarms."

The signal detection discrimination parameter d' was calculated as the normal deviate of (a) plus the normal deviate of (b). Beta (β) was calculated as the normal ordinate of (a) divided by the normal ordinate of (b).

Results. Figure 1 summarizes the effect of delay on the accuracy of classifying an old item as "old". The functions shown are for Day 1 and Day 2 sessions in the current study and for the combined data from the Rose and Fernandes study. Although the curves are very rough, they represent the course of forgetting as delays get longer. In both studies, the likelihood of recognizing an old item as "old" is almost perfect when the item was just seen. However, beyond this point, the functions for the two studies differ substantially. The curves in the current experiment show a much more gradual decline with increasing test delays. Even with the maximum delay of 36 items, the probability of correctly recognizing an old word is about .8, compared to a probability of .7 when the items are numbers. The parameters of the lag functions

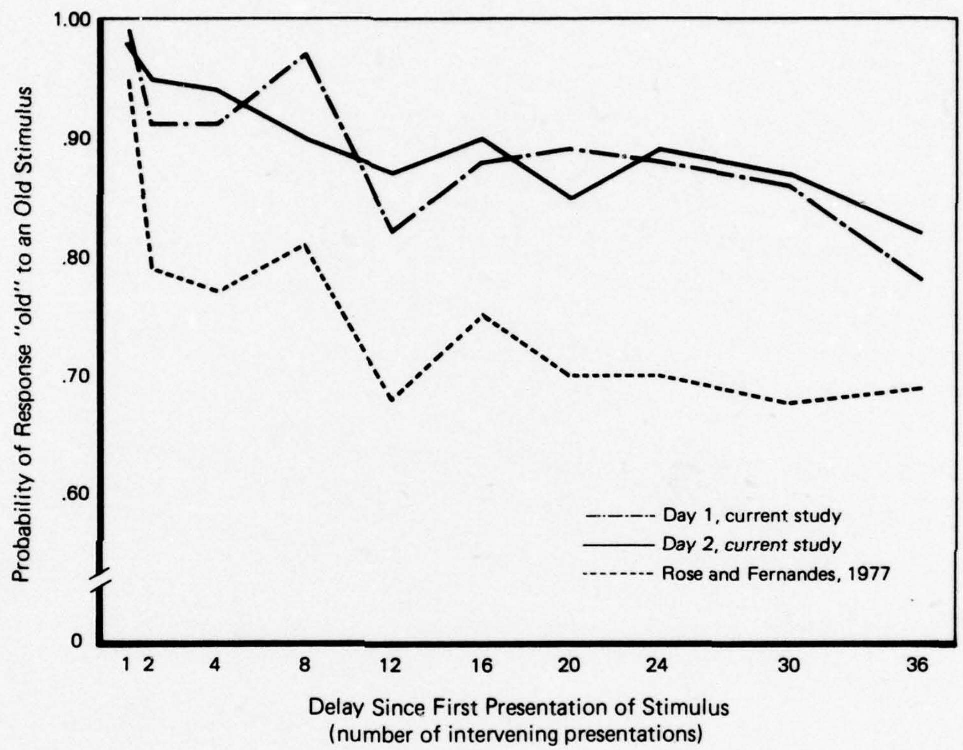

Figure 1. Lag function for the Running Recognition task.

in the current experiment, presented in Table 2, were identical for both testing sessions and hence showed nonsignificant practice effects. The reliability for each parameter was low and nonsignificant.

Overall performance on the task was quite good. Subjects correctly recognized more than 90 percent of the words presented in both sessions. Their "hit" rate was .90 in both sessions, and their "false alarm" rate was .06 and .03 for Day 1 and Day 2, respectively. All three measures had high test-retest reliability, and two of the three showed significant practice effects. Recognition in the current experiment was more accurate than recognition in the Rose and Fernandes study where the "hit" and "false alarm" probabilities were .75 and .30.

A number of subjects in the current experiment performed this task with no errors. Because the signal detection parameters d' and β are undefined under these conditions, arbitrary values of 5 and 20 were used in the analysis of these subjects' data. As a result, interpretation of group means for the two parameters is not meaningful, and a comparison between experiments is not possible. The results for these parameters have been omitted from Table 2.

Interference Susceptibility

Task description. In the Underwood et al. study, this task provided a measure of individual differences in susceptibility to interference by associations established in a series of paired-associate lists. A list consisted of five word-number pairs presented for a single study and test trial. The procedure within a set of lists remained the same across lists; the lists would contain the same words but they would be paired with the numbers in different combinations and would be presented in a different order. Subjects were presented with six sets of such lists. It was expected that performance would decrease within each set and also decrease across sets. An analysis of the number of items correct indicates that performance

Table 2

Descriptive Measures for the Running Recognition Task

Variable		N	Mean	Std. Dev.	Min.	Max.	Rel.	t-Value Day 1 vs 2
Proportion Correct	Day 1	22	.92	.05	.77	.99	.82**	2.17*
	Day 2	22	.94	.05	.81	.99		
Exponent	Day 1	22	-.044	.07	-.24	.09	.37	.14
	Day 2	22	-.042	.07	-.22	.06		
Intercept	Day 1	22	.98	.10	.69	1.12	.23	-.12
	Day 2	22	.977	.10	.79	1.21		
P ("hits")	Day 1	22	.90	.08	.62	1.00	.77**	-.60
	Day 2	22	.89	.10	.62	1.00		
P ("false alarms")	Day 1	22	.06	.06	.00	.20	.60**	-2.43*
	Day 2	22	.03	.04	.00	.20		

* $p < .05$

** $p < .01$

decreased across lists within sets as expected; however, a decrease across sets was not consistently obtained.

This task is similar to running recognition in that both create conditions where the possibility of rehearsal is minimized and the interference of preceding material is maximized. Because interference susceptibility measures recall rather than recognition, this task focuses on the storage and retrieval of information rather than on storage alone.

Procedure. Subjects were shown five word-number pairs at a rate of one pair every 3 seconds. A special slide then appeared which cued the end of the list and the beginning of the recall task. Each word was shown by itself (in a different order from that used in the study presentation) for 4 seconds, and subjects recalled the number with which it had been paired. Below is an example of a typical trial:

Subject studies list	Subject shown probe	Subject responds
NOB-5	RAP	2
HEW-4	PEG	3
JIG-1	NOB	5
PEG-3	JIG	1
RAP-2	HEW	4

Stimuli and design. In each session, there were six sets of lists, each set containing four lists. Each list within a set used the same group of three-letter words. The words in the first list of a set were paired with a number ranging from 1 to 5. In the three remaining lists of the set, the words were paired with different combinations of the same numbers. Underwood et al.'s materials were used in the first testing session. Additional words for Day 2 were generated from the Thorndike-Lorge tables in the manner described for free recall and were checked for comparability in terms of word frequency with the Underwood et al. stimuli.

Data analysis. The dependent measure on this task was the proportion of items correct per list. These data were used to calculate the means for successive lists within sets and an overall mean for each of the six sets. In addition, the slope of the best fitting line relating proportion correct as a function of list number within sets was calculated for each subject.

Results. Figure 2 indicates performance on successive lists, collapsed across sets, for the two testing sessions and for the Underwood et al. study. With the exception of the final list in the second testing session, the proportion correct decreased with successive lists, indicating that associations formed in early lists interfere with recall in later lists. The slope of the linear function, shown in Table 3, was -.03 and -.02 for the two testing sessions. These figures compare favorably with the slope of -.03 for the Underwood et al. study when their data were re-analyzed in terms of proportion correct. In both studies, recall decreased by nearly half a word from the first list to the fourth list in a set.

Although the pattern of results was similar in the two studies, subjects in the current experiment performed the task less accurately than subjects in the Underwood et al. study. The overall proportion correct (shown in Table 3) was .61 for Day 1 and .69 for Day 2. The improvement from one session to the next was significant, but performance was still well below the value of .85 obtained by Underwood et al. The test-retest correlation for overall proportion correct was high, indicating that performance was generally consistent from one session to the next.

Several reliability estimates described by Underwood et al. were calculated in the present experiment. The correlation of proportion correct for sets 1, 3, and 5 with sets 2, 4, and 6 was .87 for both days; the correlation for the sum of lists 1 and 3 across sets with the sum of lists 2 and 4 was .85 for Day 1 and .89 for Day 2. The two sets of figures compared favorably with those of Underwood et al. who obtained the same value of .81 for both calculations.

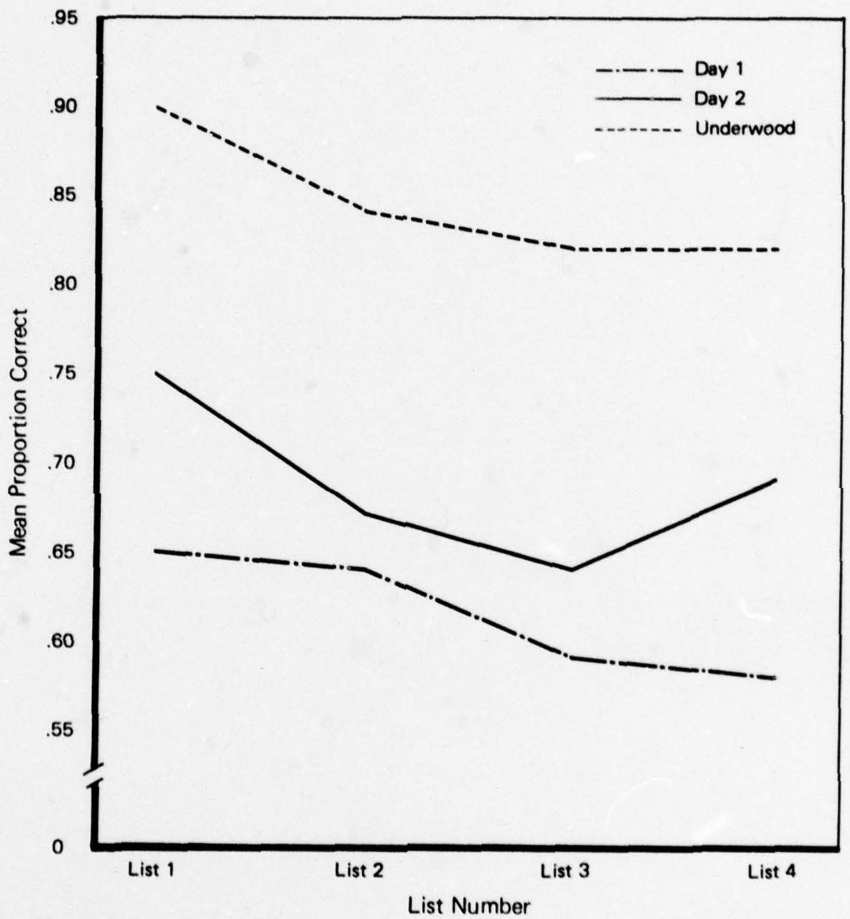

Figure 2. Mean proportion correct for successive lists within sets for the Interference Susceptibility task.

Table 3

Descriptive Measures for the
Interference Susceptibility Task

Variable		N	Mean	Std. Dev.	Min.	Max.	Rel.	t-Value Day 1 vs 2
Proportion Correct/ Total	Day 1	22	.61	.19	.29	.95	.77**	2.68*
	Day 2	22	.69	.19	.34	.98		
List Function/ Slope	Day 1	22	-.03	.01	-.16	.66	.05	.52
	Day 2	22	-.02	.04	-.10	.53		

*p < .05

**p < .01

Figure 3 shows the proportion correct on each of the sets for the two testing sessions. Although performance improves substantially from set 1 to set 2, there is considerable variability in performance on the remaining sets. Subjects generally become more accurate, scoring more items correctly on set 6 than on set 1. Overall performance is better on Day 2 than Day 1, but this, too, is not consistent across the sets.

Some subjects in the current study reported trying out different strategies for dealing with the task. Once a successful strategy was found, these subjects made very few errors on subsequent lists. This would account in part for the irregular effects of practice across the six sets of lists. It would also explain why some subjects obtained positive rather than negative slopes (see Table 3), indicating a facilitation rather than an interference effect. The low reliability for the slope measure probably reflects the subjects' efforts to find a successful strategy since test-retest correlations are sensitive to changes of this sort.

Given that running recognition and interference susceptibility provide estimates of the same construct, it was expected that performance on the two tasks would be correlated. Total proportion correct on interference susceptibility and proportion correct, hits, and false alarms on running recognition were selected for analysis because they were measures with high reliabilities in the current experiment. The correlations between the interference susceptibility measure and each of the running recognition measures were .57, .41, and -.35 for Day 1 and .49, .29, and -.32 for Day 2. All of these figures were in the direction expected, but only one of them was significant ($r = .57$, $p < .01$).

<u>Situational Frequency</u>

<u>Task description</u>. This task was selected in the present experiment to provide a measure of the "frequency" attribute of a memory representation, i.e., the ability to determine

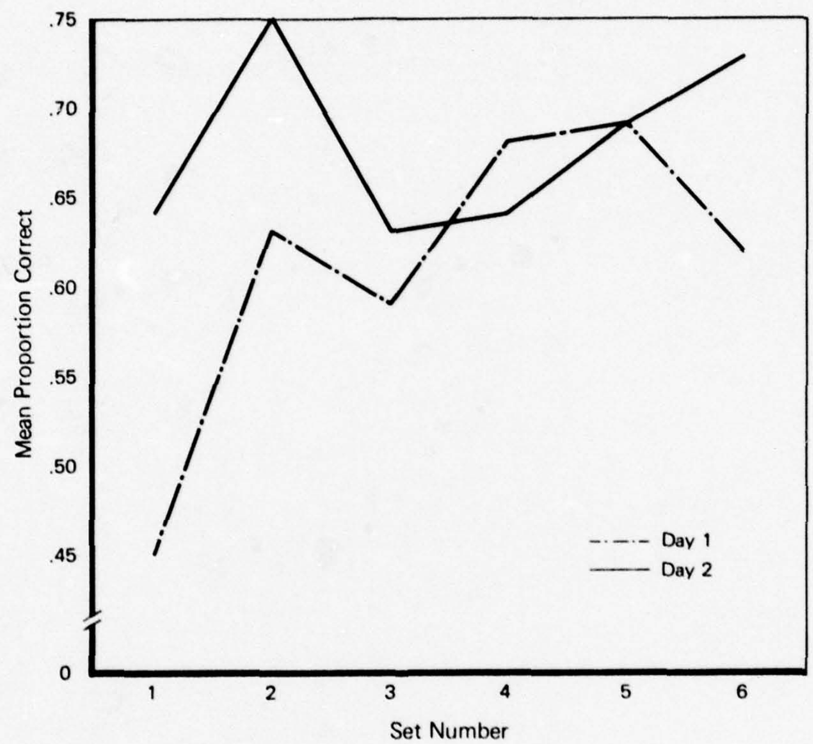

Figure 3. Mean proportion correct for each set on the Interference Susceptibility task.

the number of times that a piece of information occurs. In the Underwood et al. study, subjects were shown a list of words, then judged the frequency of occurrence of each of the words. The primary measure was the correlation between true frequencies and judged frequencies for the words.

Procedure. Subjects were shown a list of 92 words at a rate of 2 seconds per word. At the end of the list, they were given a response form containing all of the words from the list plus some that had not been presented. Subjects had 4 minutes during which to judge the actual frequency of occurrence of each word. The events in a typical trial are shown below:

Subject shown list	Subject shown word	Subject responds
elfin	starlight	"1"
starlight	quibble	"0"
limbo	elfin	"2"
artful	artful	"1"
.	.	.
.	.	.
.	.	.
elfin	limbo	"1"

Stimuli and design. Underwood et al.'s word lists were used in both sessions of the current study. Each list contained 92 words: 12 words presented once, 12 presented twice, 12 presented three times, and four presented five times. The words were all of two syllables and had Thorndike-Lorge frequencies falling between 1 and 10. For the current experiment, the twelve words that appeared in the test lists but not in the initial stimulus lists were selected according to the procedure described for the free recall task. They were comparable to the words used by Underwood et al. in terms of Thorndike-Lorge frequencies. The response form contained the 40 words from the list and the 12 additional words, presented in randomized order. Two sets of lists and response forms were prepared, one for each testing session.

Data analysis. The dependent measure was the mean judged frequencies for each actual frequency level (0, 1, 2, 3, and 5). The judged frequencies were correlated with actual frequencies, and the slope of the best fitting linear function relating these data was calculated for each subject.

Results. Figure 4 shows the relationship between actual and judged frequencies in the current experiment. Subjects tend to overestimate actual frequencies of 0 and 1, but to underestimate actual frequencies greater than 1. This pattern is more pronounced on Day 2 than on Day 1. The correlation between the frequencies, shown in Table 4, was .82 for the list used on Day 1 and .80 for the list used on Day 2. These figures compare favorably with the correlations of .87 and .85 reported by Underwood et al. for the two lists. The slope of the line relating actual and judged frequencies, also shown in Table 4, can be used to estimate the accuracy of subjects' frequency judgments. The slope was .89 on Day 1 and .90 on Day 2, indicating that subjects in the current experiment erred on the low side in their judgments.

The reliability of the correlation and slope measures was .69 and .82, respectively. The effect of practice on the two measures was small and nonsignificant.

List Differentiation

Task description. This task focused on the "temporal" attribute of a memory representation, i.e., the ability to order incoming information on the time dimension. Underwood et al. presented three successive lists of words to subjects, then asked them to indicate in which list each word had occurred. The primary response measure was the number of errors per list.

Procedure. Subjects were shown three successive lists of 20 four-letter words each at a rate of one word every 2 seconds. Subjects were cued orally and with a special slide when each list ended and the next one began. At the end of the third list, subjects were given a response sheet containing the 60

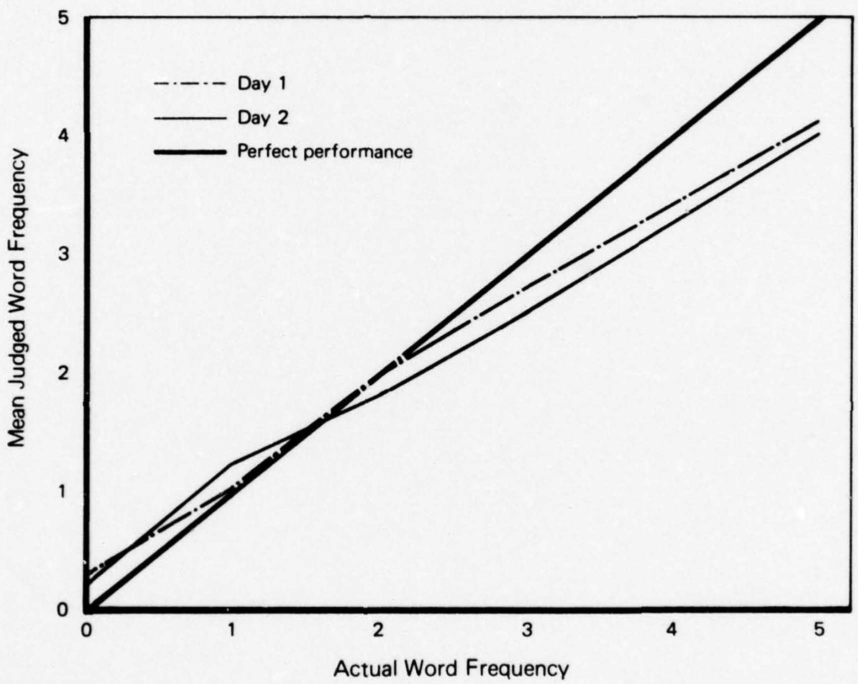

Figure 4. Mean judged frequency as a function of actual frequency for Situational Frequency task.

Table 4

Descriptive Measures for the Situational Frequency Task

Variable		N	Mean	Std. Dev.	Min.	Max.	Rel.	t-Value Day 1 vs 2
Correlation - Actual & Judged Frequency	Day 1	22	.82	.08	.61	.93	.69**	-1.39
	Day 2	22	.80	.11	.44	.90		
Judgment Function Slope	Day 1	22	.89	.16	.50	1.10	.82**	.55
	Day 2	22	.90	.21	.30	1.30		

$^{**}p < .01$

words presented in a randomized order. They were given 3 minutes during which to indicate the list (1, 2, or 3) in which the word had appeared. The events in a typical trial are shown below.

Subject shown lists	Subject shown word	Subject responds
LIST 1		
blue	also	(1) 2 3
also	sham	1 2 (3)
.	girl	1 (2) 3
.		
.	sift	1 2 (3)
stow	airy	1 (2) 3
LIST 2	lobe	1 (2) 3
lobe	stow	(1) 2 3
girl	mare	1 2 (3)
.	blue	(1) 2 3
.		
.		
airy		
LIST 3		
sift		
mare		
.		
.		
.		
sham		

Stimuli and design. Two sets of words, each set containing three lists, were presented in each testing session. Underwood et al.'s materials were used in the first session. The lists for the second session were generated from the Thorndike-Lorge tables in the manner described for free recall and were checked for comparability in terms of word frequency with Underwood et al. stimuli.

Data analysis. The dependent measure was the proportion of items correct on each list. These data were used to calculate the means for each set of lists.

Results. Figure 5 represents performance on the three lists for the two testing sessions and for the Underwood et al. study. In both experiments, the proportion correct decreases with successive lists, indicating that subjects' judgments were more accurate for words presented in earlier rather than more recent lists. Recall dropped by about half a word with each successive list.

Table 5 summarizes performance on the two sets of lists for the two testing sessions. The mean proportion correct for set 1 was .45 on Day 1 and .51 on Day 2; for set 2, the proportion was .49 and .55 for the two sessions. This translates into an improvement in judgment of about one word per set from one session to the next. This improvement was significant for both sets. Test-retest reliabilities were .83 and .70, indicating that both measures were highly reliable. The subjects in the current experiment performed the task with increasing accuracy so that by the final set of lists, performance was comparable to the level reported by Underwood et al.

Memory Span

Task description. Underwood et al. used a memory span for letters task to provide a measure of the "acoustic" attribute in memory. One set of strings contained letters with high acoustic similarity (e.g., B, C, E, G) and one set with low acoustic similarity (e.g., J, L, R, W). Subjects were presented with strings of 6, 7, 8, and 9 letters, low similarity strings first, followed by high similarity strings. Each string was scored in terms of the number of letters correct. As expected, the percent correct letters decreased considerably as string length increased. Although the difference between high and low similarity strings was reliable, the magnitude of the effect was less than expected.

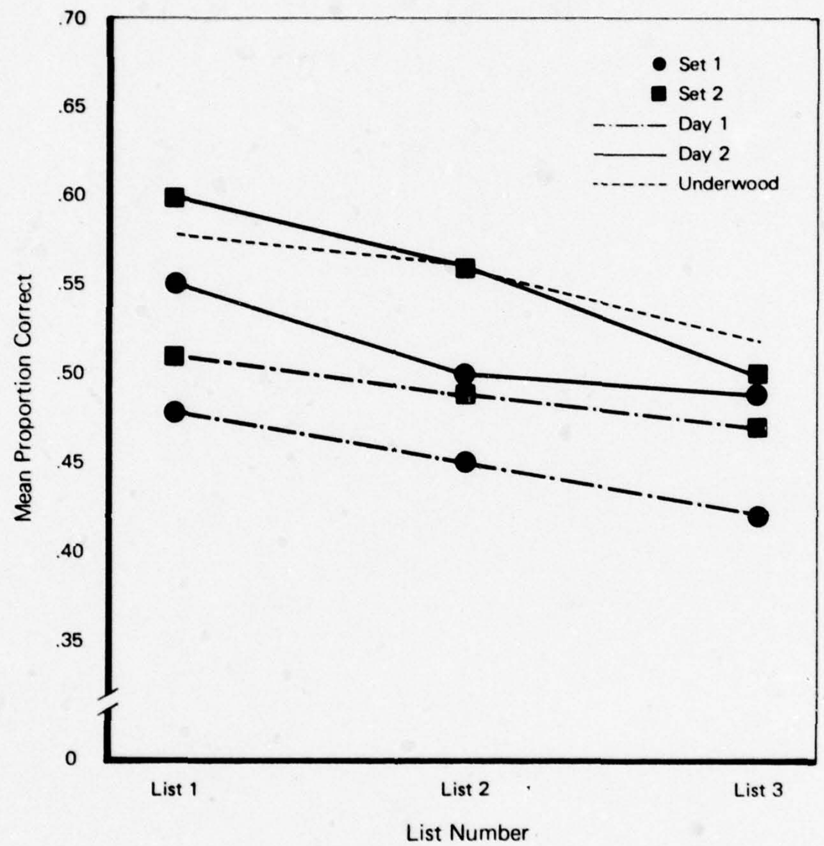

Figure 5. Mean proportion correct for successive lists on the List Differentiation task.

Table 5

Descriptive Measures for the List Differentiation Task

Variable		N	Mean	Std. Dev.	Min.	Max.	Rel.	t-Value Day 1 vs 2
Proportion Correct - Set 1	Day 1	22	.45	.17	.27	.90	.83**	2.62*
	Day 2	22	.51	.20	.22	.97		
Proportion Correct - Set 2	Day 1	22	.49	.17	.28	.92	.70**	2.12*
	Day 2	22	.55	.19	.28	.98		

* $p < .05$

** $p < .01$

This task was similar to the control condition in free recall in that both provide a measure of short-term memory capacity. In addition, the difference between high and low similarity strings was used as an indicator of individual differences in subjects' reliance on acoustic representations in memory.

Procedure. Subjects were presented with a letter string, at a rate of one second per letter. They were then given 10 seconds in which to write down the letters in the same order in which they were presented. The answer sheets were marked to indicate the number of letters in each string. Subjects were told to leave blank the appropriate spaces for letters they could not remember. The events in a typical trial are shown below.

Subject shown letters	Subject responds
Z	
D	
T	Z D T B E C
B	
E	
C	

Stimuli and design. Forty-two letter strings were presented in each testing session; half of the strings contained letters with high acoustic similarity (B, C, D, E, G, P, T, V, and Z) and half contained letters with low acoustic similarity (B, H, J, L, O, K, R, W, and Y). Subjects were presented with five practice strings of five letters each, followed by four strings each of 6, 7, 8, and 9 letters. The 16 high similarity strings were displayed first followed by 16 low similarity strings, in contrast to Underwood et al. who presented low similarity strings first.

Underwood et al.'s letter strings were the stimuli for the second session but were presented in a different order.

Data analysis. For each subject, the proportion of letters correct was calculated for each string length for both similarity types. In addition, an estimate of memory capacity was computed for both similarity types by calculating the average number of correct letters per string (i.e., number of letters correct, divided by 16, as there were 16 strings of each type per session).

Results. Figure 6 shows performance for the various string lengths and letter confusability. As expected, the proportion correct decreases with increasing string length. Performance is more accurate on Day 2 than on Day 1 and on low similarity than on high similarity strings. Table 6 presents the source table for an analysis of variance calculated on the data for this task. The effects of testing session and letter similarity were both significant ($p < .01$) as was the linear component of string length.

Although the pattern of results in the current experiment paralleled those obtained by Underwood et al., there were differences in the magnitude of certain effects in the two studies. In Underwood et al.'s study, the effect of string length was pronounced. Subjects' performance dropped from about 85 percent correct on six-letter strings to about 20 percent on nine-letter strings. In contrast, performance in the current experiment ranged from 50 to 90 percent at the shortest string length but dropped only 10 to 20 percent as the number of letters in a string increased. These performance levels probably reflect subject differences in the two studies as was commented upon previously for the other tasks. Where Underwood et al. obtained a small acoustic confusion effect, the results of the current experiment showed large and consistent differences between high and low similarity letters at every string length and for both testing sessions. The major procedural modification in the current experiment was to present the high similarity strings prior to the low similarity strings in both sessions, just the reverse of the sequence used by Underwood et al. This means

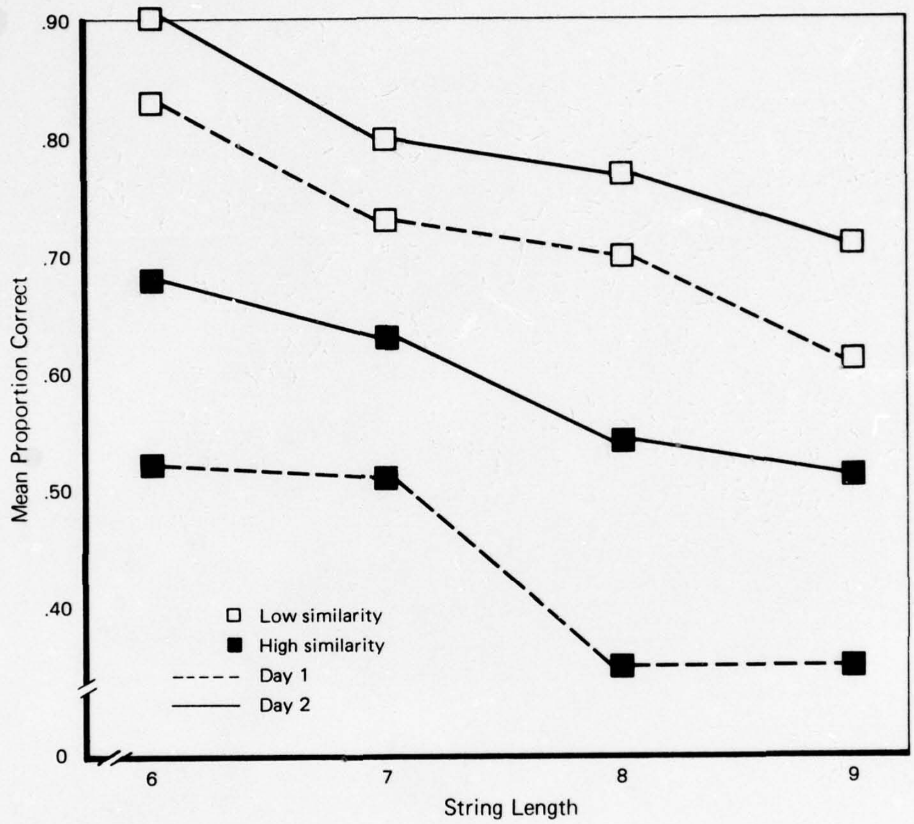

Figure 6. **Mean proportion correct as a function of string length on the Memory Span task.**

Table 6

Source Table for Mean Proportion Correct on Memory Span

Source	df_1/df_2	MS (Source)	MS (Error)	F
Testing Session (T)	1,21	.7155	.0324	22.07*
Letter Similarity (L)	1,21	4.2087	.0404	104.30*
String Length (Linear) (S)	1,21	1.2365	.0170	72.83*
TL	1,21	.0185	.0154	1.20
TS (Linear)	1,21	.0205	.0091	2.26
LS (Linear)	1,21	.0472	.0298	1.58
TLS (Linear)	1,21	.0449	.0095	4.71
Remaining Sources	8,168	.0095	.0128	< 1

* $p < .01$

that any practice effects would probably have enhanced the effect of letter confusability in the current experiment but diminished the effect in the Underwood et al. study.

Table 7 presents the results in terms of average number of correct items for high and low similarity strings and for the two testing sessions. The pattern of effects is similar to that shown in Figure 6. Memory span improved by more than half a word from Day 1 to Day 2 and by more than one and a half words from high to low similarity strings. The increase associated with testing session was significant for both types of strings. The test-retest correlations were .86 and .82, indicating high reliability in both instances.

Memory capacity as measured in this task was about 4 letters on high similarity strings and about 5.5 letters on low similarity strings. Because the maximum value possible was 7.5, these figures are considerably lower than the capacity estimate of 7 to 8 words obtained in the free recall task. Given that memory span and free recall provide measures of the same construct, it was expected that performance on the two tasks would be correlated. Table 8 shows the correlations between average number correct on memory span and proportion correct on free recall. Half of the correlations were significant, most of them associated with performance on the second testing session.

Correlations Within and Between Tasks

The inter- and intra-task correlations were calculated for the 16 measures presented in the previous section. In addition to these 16, the correlations for three other variables are included in these matrixes. These variables are the d' and β parameters from the Running Recognition task and the intercept measure from the Situational Frequency task. Although these three measures were judged as inappropriate for discussion of group effects due primarily to potential scoring artifacts which would contaminate the interpretation of the group data,

Table 7

Descriptive Measures for the Memory Span Task

Variable		N	Mean	Std. Dev.	Min.	Max.	Rel.	t-Value Day 1 vs 2
Average Items Correct/ Overall Low Sim.	Day 1	22	5.26	1.63	2.00	7.30	.86**	3.41*
	Day 2	22	5.87	1.39	2.10	7.50		
Average Items Correct/ Overall High Sim.	Day 1	22	3.60	1.25	1.70	5.70	.82**	4.43*
	Day 2	22	4.32	1.24	1.80	6.30		

* $p < .05$
** $p < .01$

Table 8

Correlations Between Memory Span and Free Recall Tasks (Day 1/Day 2)

	Free Recall		
Memory Span	Control	Concrete	Abstract
Low Sim.	.52*/.70*	.42/.63*	.34/.57*
High Sim.	.54*/.54*	.38/.65*	.13/.45

* p < .01, df = 20, one detailed test.

they were considered as potentially valuable as individual difference variables. The correlation matrixes for each day are shown in Table 9a and 9b. Because of the relatively small number of subjects, additional factor and regression analysis were not conducted.

Five of the six tasks showed significant within-task correlations on one or both days; the exception was Interference Susceptibility. Although Underwood et al. reported within-task correlations, differences in response measures in their study and the current one limit comparisons. Both studies, however, used the same measures in the Free Recall and Memory Span tasks, and the magnitude of the correlations in both tasks was similar.

Several of the inter-task correlations were mentioned in the previous section for tasks that shared the same construct and hence should have been correlated. The pattern of data in the two matrixes indicates that many of the significant correlations are between the Free Recall measures and other variables, particularly for Day 2 performance. Free Recall, List Differentiation, Situational Frequency, and Memory Span were considered to be promising tasks in the current study because they provided measures of different attributes of memory. The correlations among the four tasks, however, suggest that performance may have been dependent more upon general memory processes than upon the effects of the attributes.

DISCUSSION AND CONCLUSIONS

As mentioned above, the appropriateness of the tasks for inclusion in a test battery must be evaluated in terms of three criteria: the logistic feasibility of the adaptations, the replicability of previous findings, and the adequacy of the tasks to provide measures of individual differences. Each of these issues will be addressed in turn.

The adaptations made in the procedures and materials used by Underwood et al. were successful in the current study. The

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TABLE 9A. Inter- and Intratask Correlations for Day 1*

		Free Recall: % Correct Control	Free Recall: % Correct Concrete	Free Recall: % Correct Abstract	Running Recognition: No. Correct per 100	Running Recognition: Exponent	Running Recognition: Intercept	Running Recognition: Proportion Hits	Running Recognition: Proportion False Alarms	Running Recognition: d'	Running Recognition: β	Situational Frequency: Correlation	Situational Frequency: Slope	Situational Frequency: Intercept	List Differentiation: % Correct–Block 1	List Differentiation: % Correct–Block 2	Memory Span Letters: Mean Let. per List–High Sim.	Memory Span Letters: Mean Let. per List–Low Sim.	Interference Susceptibility: % Total Correct	Interference Susceptibility: Slope of List Means
Free Recall	% Correct Control	–																		
	% Correct Concrete	(77)																		
	% Correct Abstract	(58)	(71)																	
Running Recognition	No. Correct per 100	41	44	43																
	Exponent	20	28	15	(57)															
	Intercept	02	–00	–03	05	(-67)														
	Proportion Hits	24	36	19	(80)	(66)	10													
	Proportion False Alarms	–30	–19	–50	(-59)	–03	01	–02												
	d'	42	45	(68)	(70)	22	07	34	(-73)											
	β	19	27	(54)	31	–02	02	–03	(-57)	(87)										
Situational Frequency	Correlation	(55)	43	47	26	18	–20	05	–38	36	25									
	Slope	44	35	33	04	–11	04	–18	–21	27	35	45								
	Intercept	–21	–11	06	13	14	09	31	08	08	02	–38	–37							
List Differentiation	% Correct–Block 1	44	(68)	48	18	–04	23	17	–05	30	15	31	10	–08						
	% Correct–Block 2	31	(57)	(68)	23	19	–14	14	–21	37	24	40	12	–18	(72)					
Memory Span Letters	Mean Letters per List– High Similarity	52	42	34	25	01	05	05	–34	40	34	24	30	03	13	15				
	Mean Letters per List– Low Similarity	(54)	38	13	40	04	27	32	–25	31	15	22	33	06	–00	–12	(78)			
Interference Susceptibility	% Total Correct	(56)	(63)	44	(57)	35	–03	41	–35	45	19	45	25	06	39	40	(66)	(56)		
	Slope of List Means	–11	–20	–11	–30	–07	–12	–22	17	–16	–02	–11	–06	05	–39	–26	–07	01	–17	

* Pearson product-moment correlations rounded to the nearest hundredth; decimals omitted. For df = 20, a value of r ≥ .537 is significant at the .01 (two-tailed) level.

TABLE 9B. Inter- and Intratask Correlations for Day 2*

Task	Measure	Free Recall: % Correct Control	Free Recall: % Correct Concrete	Free Recall: % Correct Abstract	Running Recognition: No. Correct per 100	Running Recognition: Exponent	Running Recognition: Intercept	Running Recognition: Proportion Hits	Running Recognition: Proportion False Alarms	Running Recognition: d'	Running Recognition: β	Situational Frequency: Correlation	Situational Frequency: Slope	Situational Frequency: Intercept	List Differentiation: % Correct–Block 1	List Differentiation: % Correct–Block 2	Memory Span Letters: Mean Let. per List–High Sim.	Memory Span Letters: Mean Let. per List–Low Sim.	Interference Susceptibility: % Total Correct	Interference Susceptibility: Slope of List Means
Free Recall	% Correct Control																			
	% Correct Concrete	73																		
	% Correct Abstract	81	63																	
Running Recognition	No. Correct per 100	25	29	46																
	Exponent	–11	–08	11	63															
	Intercept	18	14	10	–07	74														
	Proportion Hits	–03	03	25	88	75	–14													
	Proportion False Alarms	–48	–45	–38	–29	12	–00	19												
	d'	50	35	47	21	–12	16	–11	71											
	β	40	21	36	–06	–30	18	–32	–55	90										
Situational Frequency	Correlation	55	60	66	56	11	00	22	–70	50	33									
	Slope	44	49	49	14	–06	–15	–23	–70	44	42	60								
	Intercept	–11	–35	–09	–36	–07	–13	–24	22	–03	08	–23	04							
List Differentiation	% Correct–Block 1	64	66	55	35	29	–22	19	–32	24	04	50	26	–02						
	% Correct–Block 2	71	78	68	47	23	–01	32	–24	22	01	51	25	–10	86					
Memory Span Letters	Mean Letters per List–High Similarity	70	63	57	36	03	04	14	–37	25	17	51	49	–01	45	54				
	Mean Letters per List–Low Similarity	54	65	45	46	00	17	20	–46	25	12	57	47	–34	27	41	82			
Interference Susceptibility	% Total Correct	53	49	39	49	20	01	29	–32	26	16	43	45	01	45	57	66	65		
	Slope of List Means	–12	–20	–19	–08	27	–21	11	37	–30	–33	–24	–34	02	12	–06	–24	–32	–09	

* Pearson product-moment correlations rounded to the nearest hundredth; decimals omitted. For df = 20, a value of $r \geq .537$ is significant at the .01 (two-tailed) level.

subject group used by Underwood et al. differed substantially from that in the current experiment. Whereas Underwood et al. tested college students, the AIR sample was more varied in educational background. Despite these differences, the tasks were easily and quickly administered and scored, and the subjects understood what was required of them. All of the tasks thus met the criterion of logistic feasibility.

Although subjects in the current experiment were less accurate than those in the Underwood et al. study, the results generally replicated previous findings. The major exception was the Interference Susceptibility task where some subjects reported trying out different non-memory-related strategies to avoid interference. For example, one subject mentioned that he used the initial letter of each word to form a five-letter word for a given trial. One indication of the strategy shift was the low reliability for the slope measure; another was the difference in the pattern of correlations among the slope measure and other variables in the two matrixes. Furthermore, although recall decreased across lists in a set as expected, group performance was quite variable and the effects were not robust. Because of the marked strategy shift and variability in group performance, the Interference Susceptibility task was dropped from consideration for the battery.

Judging the replicability of the Running Recognition task posed special problems since it more closely resembled a paradigm in the first AIR experiment than the task used by Underwood et al. The results of the current study indicated that the task was much easier when the stimuli were words than when they were numbers. A number of subjects performed the task with no "false alarm" errors and as a result, several of the measures were probably affected by a ceiling effect. As mentioned previously, the signal detection parameters, d' and β, were omitted from the analysis of group data for this reason. In addition, the intercept and exponent measures were probably affected. All four measures had low reliabilities (d': $r = .28$, β: $r = .20$). Although the false alarm measure was reliable, it was probably affected by a "floor" effect since performance was frequently errorless. The results did not support the inclusion of these five measures in the battery.

The between-task correlations were examined to evaluate the adequacy of the tasks to provide measures of individual differences. In making these judgments, the correlations were examined to determine if different variables were measuring different aspects of performance. If there were several "redundant" variables, the one least likely to be affected by differences in subjects' strategies was selected for inclusion in the battery. While it might be argued that strategies are critical components of task performance and therefore should be measured and retained, we consider such strategies to be inappropriate in the present context unless everyone used the same approach. If not, the same task would be measuring different things for different subjects.

Measures from several of the tasks seemed to be redundant and so some decision had to be made about which measure to retain. For the Free Recall task, the abstract nouns condition was selected since it was less likely to be affected by a visualization strategy. For the Running Recognition task, the choice was the "hits" parameter. Although either the hits or the proportion correct measure could have been used, hits was selected because it was potentially less sensitive to guessing than proportion correct. For the Memory Span task, the low similarity measure was retained since it was less susceptible to the effects of different strategies than the high similarity measure. The correlation measure from the Situational Frequency task was selected for the same reason. The List Differentiation measure, although partially interpretable in terms of a general memory ability, was also retained.

In summary, five of the six tasks met the criteria for inclusion in a test battery. All of them appear to be more related to general skill in encoding and storage than to the attributes they were supposed to measure. The results parallel those of Underwood et al. who were unable to demonstrate individual differences on a variety of attributes. However, the two experiments had different purposes. The current experiment achieved its desired outcome in that the results indicated a set of tasks and measures which provide reliable estimates of individual differences in general memory skills. These tasks have been added to those from the previous AIR experiment as candidate tasks for a test battery.

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APPENDIX A

INSTRUCTIONS FOR EXPERIMENT II

Introduction

The research you are about to take part in is one phase of a larger project designed to help understand basic human information processing capacities and limitations.

The results of this project will be used to improve educational and vocational guidance programs. The project will, for example, contribute to the matching of individual qualifications and characteristics as needed for specific jobs and to the development of training programs for various occupations and professions.

Your participation in this project will require attendance at two sessions held on consecutive days, and consisting of approximately two hours each session.

During each session you will be asked to complete a series of tasks. These tasks involve recognition and recall of letters and words, and do not test your knowledge of general information, your intelligence or your personality.

Please do not turn any pages until told to do so. Are there any questions?

Free Recall

This task involves recalling words from a list of words you will see. You will be shown six successive lists of 20 words each. When you see an asterisk (*) on the screen, this marks the beginning of a list. Each word will then be flashed on the screen for two seconds. A question mark (?) means the end of the list. As soon as you see the ?, we want you to turn to your answer sheet and write down as many of the words as you can remember. The order in which you write the words is not important but please list a word only once and try to spell it correctly. You will be allowed one minute for recall.

From previous experiments we have found that people do much better at this type of task if they first write down those words that were presented last. They then continue to recall the other words in the list. We would appreciate you adopting this strategy.

The first list you will see is a short practice list. This will be followed by six lists of words with a short break between lists. Are there any questions?

Running Recognition

This task tests how well you can recognize words that you have seen before. You will be shown a series of words. Each word will be presented one at a time for three seconds. After each word is presented, you must decide whether or not you have seen it before in the series.

Please turn to your answer sheet. If you have not seen the word before, circle "NEW" on your answer sheet. If you have seen the word before, circle "OLD" on your answer sheet. So that you can keep your place on the answer sheet, each word on the screen has been numbered as well as each line on your answer sheet.

For example, you may be shown the following words, and would answer accordingly:

shown:	answer:
1. carpet	1. (NEW) OLD
2. table	2. (NEW) OLD
3. pencil	3. (NEW) OLD
4. carpet	4. NEW (OLD)
5. hello	5. (NEW) OLD

Please work down your answer sheet. Are there any questions?

Interference Susceptibility

In this task, we are interested in how well you can remember word and number pairs. You will be shown a list of five pairs. The pairs will be shown one at a time, for three seconds each. The first part of the pair will be a three-letter word, and the second part of the pair will be a number from one to five (1-5). After the five pairs have been shown, each word will appear by itself, not necessarily in the same order just shown. You will then write down the number that was paired with that word.

The same procedure will be used on the next list. This list will contain the same words as before but they will be paired with a different combination of numbers. Also, the words will be presented in a different order than they were seen previously. And again, when each word appears by itself, you are to respond with the most recent number with which it was paired.

Let's say you are shown the following list (one pair at a time):

POP-2
INK-1
TUG-3

Then you would be shown each word by itself for three seconds not necessarily in the order in which it was presented. You would write down the numerical partner that belongs to each word.

shown:	answer:
TUG	3
POP	2
INK	1

Next, the following list would appear:

INK-2
POP-3
TUG-1

And again, you would write down the numerical partner for each word.

shown:	answer:
TUG	___
INK	___
POP	___

Are there any questions so far?

Now, please glance at the answer sheet on the following page that you will be using. Five spaces are provided to record your numbers with every list. Each word in the list will be presented only once. If you do not remember the number either make a guess or leave the space blank, and proceed to the next word. Please work down your answer sheet.

There will be four lists using the same words, each time paired with different numbers. As you may notice, there will be six sets of four lists each; each set will contain different words. Any questions?

Situational Frequency

In this task, you will be deciding how often a certain word appears in a list. You will be shown a group of words, one word at a time. Each word will be shown on the screen for two seconds. After the list of words is presented, you will be told to turn to your answer sheet. There, you will see each word again. Next to each, you must write down the number of times that the word appeared in the list. (Caution: there may be words on the answer sheet that did not appear on the screen.)

Here is an example. Let's say you were shown the following words:

judgment
certain
paper
handle
certain

On your answer sheet you would write across from each word, the number of times each occurred, like so:

Word	No. time(s) seen:
paper	1
certain	2
judgment	1
olive	0
handle	1

You will be allowed a maximum of four minutes for your answers.
Any questions?

List Differentiation

In this task you will be shown a series of four-letter words. The words will be flashed on the screen one at a time for two seconds each. A total of three lists will be shown, twenty words in each list. The first list is List 1, the second is List 2, and the third is List 3. You will be told and also shown on the screen when one list ends and the next one begins.

When you are told to do so, you will turn to your answer sheet. There you will see each of the words again, followed by a 1 2 3. You should place an "X" over the number in the list in which you think the word occurred. All of the words on the answer sheet appear on the screen.

Let's say you are shown the following:

List 1
hole
page

List 2
stop
turn

List 3
rule
ring

On your answer sheet you would mark the number of the list to which the word belongs, like so:

Word	List Number		
turn	1	X	3
rule	1	2	X
hole	X	2	3
stop	1	X	3
page	X	2	3
ring	1	2	X

We will allow you a maximum time of three minutes for your answers. Please work down your answer sheet; do not skip any words. If you do not know, make a guess.

Memory Span

For this task, you will be shown a series of letters, one letter at a time. Each letter will be shown for a second. Your job will be to remember the letter string so you can write down the letters, in the same order in which they were presented.

At the start of each trial, you will see an asterisk on the screen. The appearance of the asterisk will alert you that the next letter string is about to appear. After a short delay, the asterisk will disappear, and the letter string will be presented. At the end of the series, you will see a question mark on the screen. This is the signal for you to write down the letters you saw. Be sure to write the letters in the same order in which they were presented. You will be allowed approximately ten seconds for recall.

Are there any questions yet? Please turn to your answer sheets that we will be using. The spaces on the answer sheet mark the places for each letter to be written. If you cannot remember one or more of the letters, leave the appropriate spaces blank to show where you think they were in the series. Please work from left to right on your answer sheets.

There will be two blocks of trials; one answer sheet is provided for each block. We will have a short rest in between blocks. The first few trials of each block will be for practice. Any questions?

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