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SUBJECTIVE ORGANIZATION IN FREE RECALL OF "UNRELATED" WORDS [1]

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This paper is concerned with organization as a dependent variable in free recall verbal learning. A method will be described for measuring the extent to which subjects' recall of verbal items presented in different orders on successive trials is structured sequentially. The method assumes no knowledge on the experimenter's part as to the sources of organization, and it is thus applicable to free recall learning of any list of verbal items. The effect of repetition on organization, and the relation of organization to amount of recall will be briefly examined in a simple experiment. The method and the data are discussed in terms of the problem of the role of repetition in free recall verbal learning.

Verbal Learning and Organization

The fact that learning occurs under conditions of practice, often apparently through mere repetition of the material, is empirically well known, but theoretically not yet fully understood. Indeed, the question of why repetition leads to better recall has not been raised too often explicitly, although it has been implicit in much experimental and theoretical work.

The apparent lack of explicit interest in this problem seems to be related to the restricted aspects of subjects' behavior which are studied in verbal learning experiments. In a large majority of studies the dependent variables have been based on the operation of counting single unordered responses, assigned to categories such as "correct," "intralist intrusion," "remote backward association," and the like. Given but a single basic response variable of this kind, there is relatively little that can be done with the question of why repetition is effective, other than studying the effect of different independent variables on the rate of learning. One can be justifiably sceptical, however, of our chances of ever understanding the basic process of verbal learning by simply counting "correct" and various classes of "incorrect" responses under a variety of experimental conditions. Bolles' (1959) recent suggestion that, "If we are to understand human learning, we must determine what our *S*s are really doing" (p. 580), can be regarded as an example of growing realization that a critical reappraisal of response variables in verbal learning is overdue.

An important contribution to our understanding of the basic acquisition process might well be provided by response variables based on ordered classifications of data (Miller & Frick, 1949). Such variables are particularly interesting in the light of G. A. Miller's (1956a, 1956b, 1956c), conception of verbal learning as a direct consequence of the process of recoding or organization. Rehearsal or repetition, according to Miller, 1956b), has "the very important effect of organizing many separate items into a single unit" (p. 43). Repetition does not change the basic storage

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capacity of memory. Rather, organizing processes accompanying repetition lead to an apparent increase in this capacity by increasing the information load of individual units.

Miller's unitization hypothesis, if found tenable, has important implications for research strategy and theory in verbal learning. One of the difficulties in evaluating the hypothesis lies in the lack of appropriate measures of organization. Organization as a response variable has been investigated by many psychologists (e.g., Bousfield, 1953; Cofer, 1959; Jenkins & Russell, 1952; Rothkopf & Coke, 1961), but its measurement has always depended on the experimenter's knowledge of sources of organization present in the stimulus list. It is well known, however, that subjects are quite capable of memorizing materials which are not organized in any obvious manner, or for which the sources of organization cannot be readily specified. Thus, if the concept of organization is to have more general applicability, it seems necessary to develop methods that permit observation and quantification of organization as a response measure independent of the characteristics of the stimulus material. This is what the present paper attempts to do.

Behavioral manifestations of the hypothesized organizing process can best be studied under conditions where the order in which the subject recalls items is free to vary. Items which are organized into a single unit would then be expected to occur in close temporal contiguity in subject's recall. Repeated occurrences of such sequential patterns would indicate the existence of the organizing process, and the extent to which this occurs would provide an estimate of the degree of organization. Thus a quantitative analysis of sequential dependencies among items in subject's free recall on successive trials would yield measures of a response variable closely related to the hypothetical organizing process, independently of quantity of recall.

The method proposed in this paper is derived from information theory (Shannon & Weaver, 1949), and is quite similar to Miller and Frick's (1949) "index of behavioral stereotypy." It provides for a measure of sequential redundancy in repeated ordered samples of a set of items. As the experimental paradigm used here involves presentation of material completely free from any sequential redundancy, such redundancy or organization in subject's recall cannot be attributed to the input material. Rather, it is the subject who imposes a certain degree of organization on the material. For this reason such organization is called subjective organization (SO). In information theory terms, SO is "noise" produced by the channel, that is the subject; it is information in the output not found in the input (Miller, 1953).

MEASUREMENT OF SUBJECTIVE ORGANIZATION

Suppose we select L words, any words, and construct L different orders of these words such that each word appears in each of the L serial positions once and is preceded and followed by each other word just once. This can be done easily if $L + 1$ is a prime number. We then represent each of these L ordered lists to the subject on L separate trials. Words are shown one at a time on the memory drum. After each trial the subject is asked to record all the words that he remembers from the list, in any order he wishes. After all L ordered lists have thus been presented we have L recall records from the subject, one

TABLE 1

A SAMPLE RECALL MATRIX FOR AN INDIVIDUAL SUBJECT

nth word	(n+1)th word																	
	y_0	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9	y_{10}	y_{11}	y_{12}	y_{13}	y_{14}	y_{15}	y_{16}	n_i
x_0		1	1	2	2	1	3				2	1	1			1	1	16
x_1							1		1		9	1			2			14
x_2	1	2			1	2						2			2	2		12
x_3	2	1			1	2	1	2				2	1			1		13
x_4	1	2		1			1	5				3		1	1			15
x_5	1						2		1	8				1		2		15
x_6	1	1		1					1			1		11				16
x_7	1		1		2								1		7			12
x_8	2	2				3					2		1			4		14
x_9		1			1	1			10						1	1		15
x_{10}		1	1		1	1	3			1		1	2			1	1	13
x_{11}	1				6	1	2										4	14
x_{12}	2	1						2				1		1	1	1	4	13
x_{13}		2		9		1	2			1		1						16
x_{14}	1		9					1					2	1				14
x_{15}	2				1	3	1		1	5				1				14
x_{16}	1							2				1	5			1		10
n_j	16	14	12	13	15	15	16	12	14	15	13	14	13	16	14	14	10	$N = 236$

Note.—Recall is pooled over 16 trials.

for each trial. We then tabulate the frequency of all pairs of adjacent recall responses in a matrix consisting of $L + 1$ rows and $L + 1$ columns, and compute the measure of SO from the data in the matrix.

Table 1 shows a sample recall (output) matrix for a case where $L = 16$ and where the subjects recall responses are pooled for all 16 trials. Symbols x_1, x_2, . . . x_{16} identifying the rows refer to the 1st, 2nd, . . . 16th word in the nth position in the subject's recall list; symbols y_1, y_2 . . . y_{16} identifying the columns stand for the same words in the $(n + 1)$th position in the subject's recall list. Thus x and y represent successive positions in the subject's recall, and subscripts identify the contents of these positions, i.e., words. Symbol x_0 stands for the blank position (no word) immediately preceding the first word in the subject's recall list, and y_0 refers to the blank position immediately following the last word in the same list. The entries in the cells of the matrix show the frequency with which word i was followed by word j in the subject's recall on all 16 trials; their numerical values are symbolized as n_{ij}. Entries in the row labelled x_0 show the frequencies with which each word j stood at the beginning of the subject's recall lists on 16 trials, and similarly entries in the column y_0 show frequencies with which each word i was in the last position of the recall lists on these trials. Zeros have been omitted in the matrix. For instance, $n_{06} = 3$, which means that Word Number 6 was in the first position (followed no other word) in the subject's recall on three trials; $n_{13} = 0$, indicating that Word Number 3 never followed Word Number 1 during the 16 trials, and so forth. The numerical values of marginal totals of rows, n_i, show how many times each word i appeared in the subject's recall on all 16 trials. Marginal totals for corresponding rows and columns are of course identical. It is also to be noted that there are no entries in the cells along the main diagonal, from upper left to lower right, since normally no word follows itself in recall.

Given a recall matrix such as the one in Table 1, a number of different measures of second-order sequential organization could be used. The measure of sequential organization adopted in the present paper is essentially a measure of redundancy in a sequence of events when the probabilities of successive pairs of events are known or can be estimated:

$$C_x(y) = 1 - \frac{H_x(y)}{\max H_x(y)} \qquad [1]$$

$H_x(y)$ here refers to the amount of information (uncertainty) in the event y when the preceding event x is known, and *max* $H_x(y)$ stands for the maximum value of such uncertainty. This is Miller and Frick's (1949) second-order index of behavioral stereotypy. The formula for computing second-order SO involves a minor modification of the above formula,[2] simplifying calculations in addition to being somewhat more appropriate to the free recall learning situation. This formula is as follows:

$$\mathrm{SO} = \frac{\sum_{i,j} n_{ij} \log n_{ij} - \min \sum_{i,j} n_{ij} \log n_{ij}}{\sum_{i} n_i \log n_i - \min \sum_{i,j} n_{ij} \log n_{ij}} \qquad [2]$$

where n_{ij} represents the numerical value of the cell in the ith row and jth column, n_i represents the marginal total of the ith row, and $\min \sum_{i,j} n_{ij} \log n_{ij}$ represents the minimum value that $\sum_{i,j} n_{ij} \log n_{ij}$ can assume.

In cases where no marginal total n_i exceeds the length of the list L, $\min \sum_{i,j} n_{ij} \log n_{ij}$ is equal to 0, and Formula 2 reduces to the following relatively simple expression:

$$\mathrm{SO} = \frac{\sum_{i,j} n_{ij} \log n_{ij}}{\sum_{i} n_i \log n_i} \qquad [3]$$

In this formula $\sum_{i} n_i \log n_i$ can be regarded as a measure of maximum organization, $\sum_{i,j} n_{ij} \log n_{ij}$ represents the actual organization, and SO is simply a measure of actual organization relative to the maximum. Thus SO can assume all values between zero and unity, the former expressing the complete absence of second-order sequential organization, as in the case of the ordered stimulus lists presented to the subject, and the latter the maximum degree of such organization, as in the case of an imaginary subject who recalls all words on all trials exactly in the same order. SO for the data in Table 1, incidentally, is .397.

So far we have considered only second-order sequential organization,

[2] *Max* $H_x(y)$ in Miller and Frick's index of behavioral stereotypy is defined as *max* $H(x,y)$ − *max* $H(x)$. Thus it is based on the assumption that all responses are equally frequent. For the present problem, however, it may be somewhat more meaningful to compute *max'* $H_x(y)$ on the basis of the *given* frequency of individual responses, i.e., as determined by subject's recall:

$$max'\ H_x(y) = max\ H(x,y) - H(x)$$

If *max'* $H_x(y)$ is substituted for *max* $H_x(y)$ in Formula 1, that formula becomes mathematically equivalent with Formula 2, the measure of subjective organization as used in this paper.

based on pairs of successive responses. The method can be easily extended to higher-order dependencies, even though the computational labors involved would become quite prohibitive. However, estimates of higher-order organization can be obtained more easily. For instance, instead of setting up a three dimensional matrix for calculating third-order SO, we can tabulate data in a two dimensional matrix with nth items as rows and $(n + 2)$th items as columns. In this case we also need two rows for blank spaces preceding the first word (x_0 and x_{0-1}), and two columns for blank spaces following the last word in each recall list (y_0 and y_{0+1}). This procedure amounts to collapsing the three dimensional matrix along the $(n + 1)$th dimension. That is, we are computing an SO measure based on pairs of responses *separated* by one response. Such an SO is labeled SO (Lag 1), and it does provide an estimate of the third-order SO. In a similar manner, still higher order dependencies can be evaluated. SO (Lag 2) is an estimate of the fourth-order sequential organization, SO (Lag 3) is an estimate of the fifth-order SO, and so forth.

SO can be calculated for any block of trials, usually successive trials. Thus it is sometimes useful to indicate the size of the block on which the measure is based. For instance, SO (Blks = 3) means SO calculated from blocks of three successive trials. SO for a single trial is not meaningful, as subjective organization is defined in terms of the subject's tendency to recall words in the same order on successive trials; in fact SO for a single trial, when calculated according to the formulas given, turns out to be 0, provided that the subject has not repeated any pairs of words.

DEMONSTRATION EXPERIMENT: SUBJECTIVE ORGANIZATION AND PERFORMANCE

The following simple experiment will serve as an illustration of how the method works, and the data from the experiment will provide tentative answers to three questions which can be raised in the context of the discussion of the concept of organization in the first section. The questions are as follows: First, do the subjects actually organize "unrelated" words when instructions are simply to recall as many words as they can? Second, does this subjective organization , if found in the data, increase with repetition of the material? Third, is there a systematic relation between subjective organization and more traditional measures of learning, such as the number of words correctly recalled?

Procedure

A list of 16 English words was adopted from another verbal learning experiment (List III in Tulving & Thornton, 1959). All words were disyllabic nouns, consisting of five, six, or seven letters. The words, here listed alphabetically, were as follows: ACCENT, BARRACK, DRUMLIN, FINDING, GARDEN, HOYDEN, ISSUE, JUNGLE, LAGOON, MAXIM, OFFICE, POMADE, QUILLET, TREASON, VALLEY, WALKER. Sixteen different sequences of these words were constructed such that, considering any block or all 16 orders of the stimulus list, there was no second-order or higher-order redundancy in the lists.

Sixteen female undergradute students enrolled in the introductory psychology courses at the University of Toronto served as subjects. Their median age was 19 years. None of the subjects had previously participated in any verbal learning experiments.

Each subject was tested individually. In the instructions the subject was told that her task was to learn a list of 16 words, two-syllable English nouns, that would be presented to her on 16 separate trials. At the end of each trial she was to write down as many words from the list as she remembered. Then she would be shown the same words again, in a different order, and at the end of the trial she would again write down all the words that she was able to recall. The subject was also told that the order in which she recalled the words did not matter, her task was simply to recall as many of the words on each trial as she could.

The 16 different orders of the stimulus list were typed on white paper in lower case letters and presented to the subject on a memory drum. The rate of exposure was one word per second. At the end of the trial the subject was given 90 seconds to record her recall on sheets of paper lined with 16 consecutively numbered lines.

The order in which the 16 ordered lists were presented to the subjects was systematically counterbalanced among subjects. The method used for assigning the 16 orders of the stimulus list to the 16 subjects on the 16 trials was the same as that used in assigning the 16 words to 16 serial positions in 16 orders of the stimulus list.

Results

Two kinds of data are of interest in this experiment, performance (P) defined in terms of frequency of correct recall, and subjective organization (SO). Extralist intrusions and misspelled words from the list were ignored in computing both P and SO scores.[3] Repetitions of list words within a given trial were included in the recall matrix and thus entered the SO score, but not the P score. The mean number of extralist intrusions, together with misspelled words, was 0.13 per trial, the mean number of repetitions of list words was 0.09 per trial.

Second-order SO scores were calculated for successive blocks of two trials (SO, Blks = 2), for running blocks of three trials (SO, Blks = 3), and for the total block of 16 trials

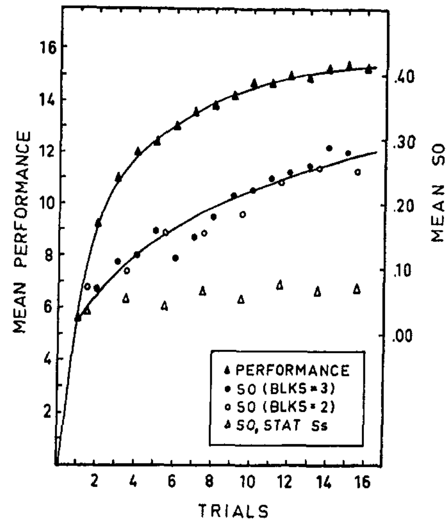

FIG. 1. Mean performance (upper curve) and mean SO (lower curve) as a function of trials. (Values of performance are to be read from the left ordinate, SO from the right ordinate. Mean SO for blocks of two trials from 16 statistical subjects are shown for comparison, open triangles. For further explanation see the text.)

(SO, Blks = 16). SO (Blks = 2) scores were also computed for 16 statistical subjects.[4]

The effect of repetition on both P and SO is summarized graphically in Figure 1. The values of P are to be read from the left, the values of SO from the right hand ordinate. The abscissa represents trials. The upper curve is the typical learning curve, showing performance as a function of trials. The lower curve, fitted by inspection to data points representing SO (Blks = 3), could be called an

[3] Such extralist intrusions are of interest in their own right and may provide valuable information about the organizing process. In order to handle them in the present situation, the recall matrix can be simply extended. However, such intrusions can probably be better studied in different experimental situations (e.g., Deese, 1959).

[4] IBM Model 650 Electronic Data Processing Machine was used in these calculations. Thanks are due to Albert S. Bregman for constructing the program. Data from statistical subjects, whose "performance" was matched with that of individual experimental subjects, were collected as an attempt to estimate the amount of organization occurring by chance, since the sampling distribution of SO, under the null hypothesis of no organization, is not known.

"organization" curve. The SO for each block is plotted against the middle trial of the block. Thus there are 14 SO (Blks = 3) scores. SO scores for successive blocks of size two are also shown for both the real and the statistical subjects, plotted against the midpoints of the trial blocks.

These data clearly demonstrate that subjects do in fact organize their recall sequentially even in the absence of such sequential organization in stimulus lists, and that this organization increases systematically with repeated exposures to, and recall of the material. Thus, in an experimental situation such as the present one, repetition has two parallel effects: increasing frequency of recall is accompanied by an increasingly tighter sequential organization.

The slopes of the two curves depicted in Figure 1 seem to be different. When mean P scores are plotted against mean SO (Blks = 3) for the 14 trials, the curvilinearity of the relation is obvious. However, the relation becomes quite linear when a logarithmic transformation is applied to the mean SO scores, suggesting that, as a first approximation, increase in performance is proportional to increase in log SO. The product-moment correlation between mean P and log mean SO (Blks = 3) for Trials 2 to 15 was found to be +.96.

Estimates of higher-order SO were obtained in the form of SO scores for Lags 1, 2, and 3, for the total block of 16 trials. The mean SO (Blks = 16) scores for these lags and their standard deviations are shown in Table 2, together with comparable data from the statistical subjects for Lags 0 and 3. Even though mean SO scores seem to decrease with increasing lags, it is interesting to note that SO (Lag 3, Blks = 16) scores are higher than the same scores from the statistical subjects. The median test yielded a chi-square of 15.12, which is highly significant.

TABLE 2

MEANS AND STANDARD DEVIATIONS OF SO (Blks = 16) FOR VARIOUS LAGS

Group	Lag 0	Lag 1	Lag 2	Lag 3
Experimental subjects				
Mean	.292	.224	.223	.216
Standard deviation	.054	.045	.034	.035
Statistical subjects				
Mean	.180			.169
Standard deviation	.017			.012

Note.—N = 16 for each group.

TABLE 3

INTERCORRELATIONS AMONG SO (Blks = 16) MEASURES FOR LAGS 0, 1, 2, AND 3; AND CORRELATIONS BETWEEN THESE SO SCORES AND MEAN P SCORES ON TRIALS 1 TO 8, 9, TO 16, AND 1 TO 16 FOR INDIVIDUAL SUBJECTS

Measures	SO			
	Lag 0	Lag 1	Lag 2	Lag 3
SO (Lag 1)	+.86			
SO (Lag 2)	+.62	+.85		
SO (Lag 3)	+.58	+.74	+.84	
P (Trials 1 to 8)	+.45	+.32	+.24	+.01
P (Trials 9 to 16)	+.78	+.61	+.34	+.19
P (Trials 1 to 16)	+.63	+.47	+.30	+.08

Note.—N = 16.

The intercorrelations among SO (Blks = 16) scores for Lags 0, 1, 2, and 3, as well as correlations between these SO scores and several average P measures are shown in Table 3. These correlations are based on individual data from 16 subjects.

Certain orderly relations appear in Table 3. First, the correlations between any two adjacent SO measures on the lag dimension are reasonably high, all three listed in the table being approximately +.85. Second, with increasing distance on the lag dimension between any two SO measures the correlations decrease. Thus, for example, SO (Lag 0) has a correlation of +.85 with that for Lag 1, +.62 with Lag 2, and +.58 with Lag 3. Third, correlations between P and SO decrease with increase in the lag of the SO measure. The most important conclusion to be drawn from these data is that, within the limits of the present method, the second-order SO is about as useful a measure of sequential organization as that based on any combination of different orders, and more useful than any other single higher-order SO measure.

Positive correlations between SO and P scores in Table 3, where correlation is done on data from 16 subjects, support the observation of the same relation over trials. It is also interesting to note that on the basis of a single estimate of organization for each subject, that based on the total block of 16 trials, SO accounts for a larger amount of variance in the P variable for Trials 9 to 16 than for Trials 1 to 8.

All the above findings relate to organization as an intrasubject phenomenon. Commonality of organization between subjects, however, can also be investigated by using the same general method. That there might be such commonality became apparent in the inspection of recall data from different subjects. Recall matrices from individual subjects showed that quite often the patterning of response sequences was similar for many subjects. This phenomenon was investigated in two ways.

First, the recall data from all 16 subjects were pooled for all 16 trials and entered into an "intersubject recall matrix." If all subjects organized their recall differently, the distribution of cell entries in the group recall matrix would not be significantly different from the distribution under conditions where only chance factors

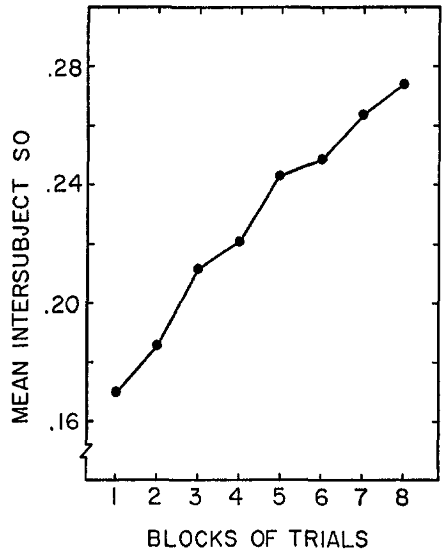

FIG. 2. Mean intersubject SO scores for 16 subjects on eight successive blocks of two trials.

are operating. To test the significance of the apparent deviation of the data in this matrix from chance distribution, the information function $T(x,y)$ was computed. It was found to be 0.352 bits which is significant at better than .01 level, using the method suggested by Miller (1955). This finding thus confirms the casual observation that there is a certain degree of commonality in the subject's recall.

The second method used to explore intersubject organization was as follows. For a single trial data were pooled in a recall matrix from all 16 subjects. For each such intersubject recall matrix SO was computed. This procedure results in 16 intersubject SO measures, one for each trial. These data are shown in Figure 2. Intersubject SO measures have been averaged for blocks of two trials, in order to smooth the curve. In view of the orderly increase in the intersubject SO measure with repetition, it would seem safe to conclude that the commonality of organized recall sequences between subjects increases with repetition of the material.

DISCUSSION

All three questions posed at the beginning of the experiment have been answered in the affirmative. It seems that the subjects do impose a sequential structure on their recall, that this subjective organization increases with repeated exposures and recall of the material, and that there is a positive correlation between organization and performance. None of these findings is very surprising, and all are in good agreement with related experimental evidence. Bousfield and his associates, as well as other investigators, have amply demonstrated that there is a strong tendency in subjects to recall randomly presented material in sequences of related words or clusters (Bousfield, 1953; Cohen & Bousfield, 1956; Jenkins & Russell, 1952). It has also been shown that repeated presentations of the stimulus word list increases this clustering tendency (Bousfield & Cohen, 1953), and that there is a direct relation between the degree of clustering and the amount of recall (Bousfield & Cohen, 1955; Bousfield, Cohen, & Whitmarsh, 1958; Jenkins, Mink, & Russell, 1958; Sakoda, 1956). The findings of the present experiment extend the domain of these phenomena of organization from one trial recall and experimentally organized materials, as used in all the above experiments, to a learning situation, with several successive trials, and experimentally unorganized materials.

The finding that the organizing effects, well demonstrated in experiments on clustering, can be experimentally assessed even in case of unrelated words, is quite encouraging. Perhaps paradoxically this suggests that a list of completely *unrelated* words is probably as fictional as is a truly nonsensical nonsense syllable. It is for this reason that reference has been made throughout this paper to "unrelated" words, referring only to the fact that words are experimentally unselected as to their meaning.

The present method of quantifying sequential organization in free recall learning constitutes only a rather coarse net for capturing the process of organization in all its diversity. For one thing, the SO measure is most sensitive to rigid sequences of responses, or chunks (Miller, 1956c). It is quite likely, however, that a great deal of organization occurs in the form of clusters (Bousfield, 1953), in which items have no fixed order. This would tend not only to attenuate measures of SO, but also, through increased variability of SO, depress correlations with the performance variable.

It would be interesting, in view of Miller's unitization hypothesis, to look at organization in terms of its units. In many cases subjects undoubtedly impose a hierarchical organization on recall, or use a Plan (Miller, Galanter, & Pribram, 1960). In other cases, particularly when the list to be learned is short and some coding device such as the alphabet can be employed, nonhierarchical organization may also occur. The present method does not lend itself to an identification of various strategies adopted by subjects, even though casual inspection suggests many diverse sources of organization: associative grouping, conceptual categories, assonance, grouping in terms of familiarity of items, and so forth.

The method provides only an overall measure of organization. This measure is related to the size of the organizing units in a systematic manner, but the relation cannot be easily specified. The two extremes of the function, however, are determined by the definition of the SO measure, and the transition from one to the other must be gradual. In one case the units of organization are individual items in the list, resulting from previous response integration (Mandler, 1954) outside the laboratory. In this case the probability of two or more items being recalled consistently together is no greater than what might be expected by chance, and the numerical value of SO is approximately the same as that of statistical subjects. On the other extreme, the whole set of items is organized into one unit, and SO is at the maximum.

Assuming a systematic relation between the size of the organizing units and the numerical value of SO, the finding that the second-order SO accounts for a larger proportion of variance in individual P scores than do estimates of higher-order measures makes good sense. Some units of organization contain only two items, and, given a flexible order of units in recall, these are not tapped by the third-order and higher-order measures of SO, while the second-order measure is sensitive to all units of two or more items. This interpretation is also consistent with the observed intercorrelations among SO measures for different lags. Although these measures are all based on identical sequences of responses, the correlations are less than perfect. This probably reflects the fact that distributions of size of organizing units vary from subject to subject.

What is the significance of the method and the preliminary findings for the question originally posed about the effects of repetition on performance? It seems that response variables such as SO, based on ordered classifications of data, might be quite useful in our attempts to shed more light on the nature of the acquisition process in verbal learning. And the present findings seem to have contributed to the attractiveness of Miller's unitization hypothesis (1956a) as a serious beginning of a useful theory of free recall verbal learning. Even though intuitively there seems little doubt that performance depends on organization, the correlational design used in the present study does not yet permit such a conclusion, and other kinds of experiments are necessary. Given a method of quantifying behavioral manifestations of the organizing process, it is quite possible to test many implications of the unitization hypothesis.

It is to be noted that the concept of repetition has been specified here rather loosely. There are at least two operationally distinguishable phases which should be studied separately, presentation of material and test for recall. A conceptual and experimental clarification of this important concept is clearly needed.

The observation of common recall sequences among different subjects and of increased stereotypy of such intersubject organization under conditions of practice very strongly suggests, or rather confirms the expectation, that sources of organization are discovered by subjects in the material, rather than invented idiosyncratically. Many task variables, therefore, are expected to influence both subjective organization and recall of the material, and a systematic exploration of these relations constitutes an important part of the research program designed to evaluate the tenability of the unitization hypothesis.

SUMMARY

A method for examining and quantifying sequential dependencies in the subjects' free recall of words on successive recall trials has been presented. Subjective organization as a depend-

ent variable was defined in terms of the subject's tendency to recall items in the same order on different trials in the absence of any experimentally manipulated sequential organization among items in the stimulus list. In a preliminary experiment it was found that the subject's recall behavior manifests such subjective organization, that this organization increases with repetition, and that there is a positive correlation between organization and performance. These data were discussed with reference to the problem of the role of repetition in free recall verbal learning.

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