Rule utilization in free recall[1]

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Subjects were exposed to 20 trisyllabic nonsense words, at either 70% or 0% redundancy, in a multitrial free-recall experiment. Superior recall was found for the highly redundant words. In addition, sequences of syllables which recurred in the redundant stimuli were introduced into the nonredundant words, but recall of nonredundant words containing these sequences was not superior to recall of the remaining nonredundant words. It was concluded that when prior associations are not present, differential recall may be explained by the encoding mechanism used by the Ss as a result of organizational properties inherent in the stimuli.

The literature concerning verbal learning has stressed association principles. Prevalent associationistic explanations of free recall implicitly emphasize the retrieval process, as Tulving (1968) has pointed out. For example, Underwood (1964) found that lists of words which could be conceptualized as belonging to several categories were more easily recalled than lists which seemed to have no basis for such categorization. It was suggested that the basic memory unit is the category name which evokes converging implicit responses and consequently facilitates memory of particular words. Deese (1959) has suggested that free recall depends upon the tendency of free associations from within the list to converge upon other items within the list, as a function of the interitem associative strength.

Anisfeld & Knapp (1968), on the other hand, have seemingly demonstrated that the initial encoding of stimuli, as measured by false recognition, plays an important part in subsequent retrieval. They suggested that words consist of complexes of semantic, syntactic, and other features, and that words are not reproduced from memory but reproduced from their component features. Accordingly, associative responses are viewed as the selection of only certain prominent (primarily semantic) features from the larger population of features. Ss should, however, be able to utilize features other than those due to prior associations as cues for retrieval.

In an effort to reduce prior associations among stimuli some investigators have used nonsense words in free recall paradigms. Miller (1958) studied free recall using redundant strings of letters, where redundancy referred to the generation of stimuli by deterministic rules, resulting in recurring letter sequences. He found that in multitrial free recall, the Ss exposed to the redundant stimuli were able to reproduce significantly more words than Ss exposed to randomly generated words. Miller stated that the facilitation in recall of redundant strings was probably due to the Ss' recoding of the redundant strings in terms of their generation rules.

Evans (1967) has proposed a mechanism for rule learning and encoding which is similar in some respects to Anisfeld and Knapp's conception. Evans has proposed that the stimulus can be regarded as a vector of quantitative attributes. These attribute vectors can be used to map objects into points in multidimensional space, with a concept corresponding to a cluster of points. The center of each cluster may be regarded as the rule or schema for points falling within the cluster. The rest of the points falling within the cluster can be encoded (Attneave, 1957; Oldfield, 1954) in terms of schema plus correction, or schema plus deviations from the schema.

Horowitz (1961) has defined intralist similarity by the number of letters used for generation of nonsense trigrams. He found early facilitation for recall of words from a high-similarity list as opposed to words from a low-similarity list. Koeppel (1968) has recently found that high-similarity lists will continue to show superior recall if they also possess "good form," or correlations between letter positions, i.e., one letter in a specific position consistently followed by another specific letter. This is equivalent to saying the stimuli are redundant.

At least two explanations could be offered for the increased recall of words from high intralist similarity lists which exhibit "good form." First, one could argue that the facilitation is due to the learning and use of stimulus generation rules for encoding the stimuli with a subsequent decrease in the amount of information stored, as schema theory or Miller's adopted chunk hypothesis implies. A second argument, based on a frequency hypothesis, would emphasize that facilitation occurs because of the associations built up between recurring sequences of letters or syllables.

Two hypotheses were investigated in the present investigation. First, redundant words will be more easily recalled in a multitrial free recall task than nonredundant words. Second, recall of rule-generated words will be superior to recall of words from a nonredundant list incorporating the same recurring syllable sequences which occur in the redundant list.

Table 1
Serial Lists of Linguaforms and Generation Rules

Redundant linguafor linguaforms   Nonredundant linguaforms

Redundant linguaforms	Nonredundant linguaforms
GEKOKO	GAKOGE
TAVINU	SUGAGA
*VIGA*DU	*VIGA*TA
GA*DUNU*	TA*DUNU*
*NUSU*GE	*NUSU*GA
GENUNU	VIBUNU
NUTAGE	GEVIDU
SUGEGA	GAVIKO
TAVISU	NUGATA
GEGABU	GENUVI
TAGEKO	VISUVI
NUVINU	GAKODU
GA*BUTA*	GA*BUTA*
*DUNU*TA	*DUNU*GA
VI*NUSU*	TA*NUSU*
KO*VIGA*	DU*VIGA*
TAVITA	TAVIGE
GADUKO	VITASU
GEKOVI	SUTANU
*BUTA*VI	*BUTA*GE

Rule (schema) 1: TA GE KO VI GA DU NU
Rule (schema) 2: BU TA VI NU SU GE GA

SUBJECTS

The Ss were 40 undergraduate students enrolled in introductory psychology classes. The Ss were divided into equal groups by their order of appearance for the experiment.

STIMULI

The procedure used for stimulus generation has been discussed elsewhere (Hollier & Evans, 1967). The two lists of stimuli, one generated at 70% redundancy, the other at 0% redundancy, are shown in Table 1. Nine two-letter syllables were selected to be included in the sampling domain. The syllables were selected because they occur infrequently in the English language, and because the second letter in each syllable is a rare associate for the first letter (Underwood & Schultz, 1960), yet their combinations do not form words in the English language. Two most probable sequences of seven syllables were constructed from the nine syllables as shown at the bottom of Table 1. A schema or generation rule can be defined as the most probable sequence, or the sequence of syllables in a particular order, and stimuli formed by a probabilistic procedure from these rules can be said to constitute a schema family. The redundancy level can be manipulated by the probability of one syllable following another syllable in the most probable sequence. Ten stimuli were generated by use of each of the schema rules for the 70% list. Ten 0% redundant stimuli were generated by use of a random number table from the population of syllables defining the domain of each schema rule for the 0% list.

Some of the segments of the words in

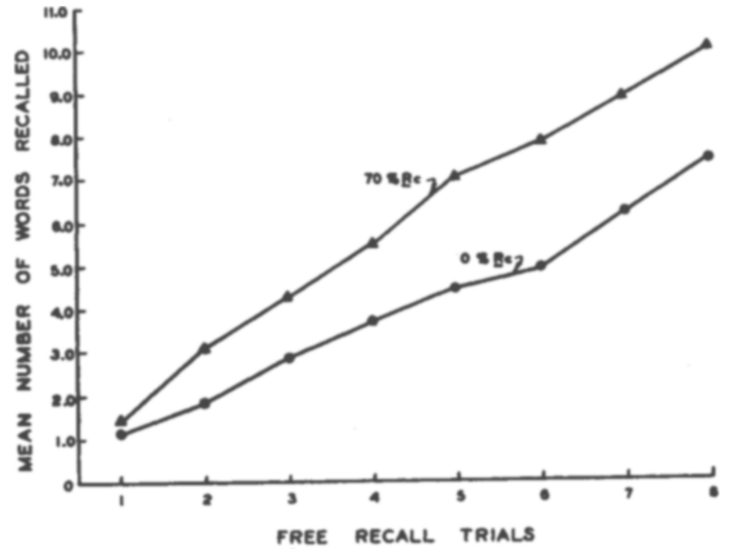

Fig. 1. Free recall as a function of Rc and trials.

both lists have been italicized in Table 1. These segments were selected arbitrarily from the redundant list and introduced into exactly the same position in the nonredundant words. Words containing these segments were designated "marker" words. Both lists meet Horowitz's criterion (1961) of high intralist similarity, while only the 70% list and the "marker" words in both lists might be thought of as exhibiting what Koeppel (1968) defines as good form.

PROCEDURE

The Ss were run in groups of three or less and were seated at a table directly in front of the E. Stimuli were printed in large letters on 4 x 6 in. cards. The Ss were instructed to try to remember the stimuli they saw and to write down as many of them as they could when instructed to. The E then began turning over the stimulus cards at 5-sec intervals. After having gone through all 20 cards of one list, the Ss were allowed 2 min to write down all the words they could remember. This procedure was repeated eight times, with an intertrial interval of 10 sec allowed for the Ss to turn the answer booklet page.

RESULTS

In order to test the hypothesis that recall of redundant words would be superior to recall of nonredundant words, a two-way analysis of variance was conducted with redundancy level and trials as variables. The main effect of redundancy was significant ($F = 13.70$, $df = 1/38$, $p < .01$), as were trials ($F = 95.16$, $df = 7/266$, $p < .01$), and the Redundancy by Trials interaction ($F = 3.39$, $df = 7/266$, $p < .01$). The mean number of correct responses for the two lists as a function of trials is shown in Fig. 1.

A similar analysis of variance was performed using "marker" words recalled as the dependent variable to test the second hypothesis. The redundancy variable was significant ($F = 5.89$, $df = 1/38$, $p < .05$), as were the trials variable ($F = 38.47$, $df = 7/266$, $p < .01$), and the Redundancy by Trials interaction ($F = 2.39$, $df = 7/266$, $p < .05$). The mean number of "marker" words recalled for the two lists as a function of trials is shown in Fig. 2. On the last recall trial, Ss trained on the nonredundant list recalled a mean of 7.5 words, and a mean number of 2.5 "marker" words. Since 8 of the 20 words in this list were designated as "marker" words, it can be concluded that the recurring syllable combinations by themselves did not facilitate recall.

DISCUSSION

The present results (Fig. 1) extend Miller's (1958) finding that rule-generated stimuli are more easily recalled. Several differences, however, must be pointed out between his study and the present one. First, Miller used a finite state grammar for generating stimuli, while a probabilistic procedure was used here. The latter procedure produces some sequences of syllables which deviate from the generation rules, making the discovery of the generation rules more difficult. Second, Miller's generation procedure resulted in the "schema" (SSG or NNSG), or organizational rule, being reproduced in each word. One strategy would consist of learning these basic strings, and then remembering where other letters were added. In the present study, however, the whole schema rule could not be represented in each word so that facilitation via the use of the rules used for the generation of the stimuli would have to result from the abstraction of the rules from many stimuli.

The finding that frequency of recurring syllable sequences alone, i.e., the "marker" words in the 0% list, does not facilitate recall suggests that rule or schema learning consists of more than a frequency hypothesis. That is, if associations are formed between words having common elements or sequences, these associations do not facilitate recall in the absence of some other organizational factor or schema rule. It can be suggested that rule learning and subsequent economy in encoding (schema + correction) facilitates recall merely as the result of the amount of encoded information. This interpretation emphasizes the role of stimulus encoding rather than the retrieval mechanisms that an associationistic interpretation implies. These results may also imply that Koeppel's (1968) finding of facilitation for recall of words exhibiting "good form" was due to the economy of encoding and storage.

The results presented suggest, as Miller (1958) and Underwood (1964) have previously stressed, that in the absence of prior associations, rule learning or concept formation can play an important part in verbal learning. It is also likely, as Anisfeld & Knapp (1968) have demonstrated, that stimulus attributes other than associations

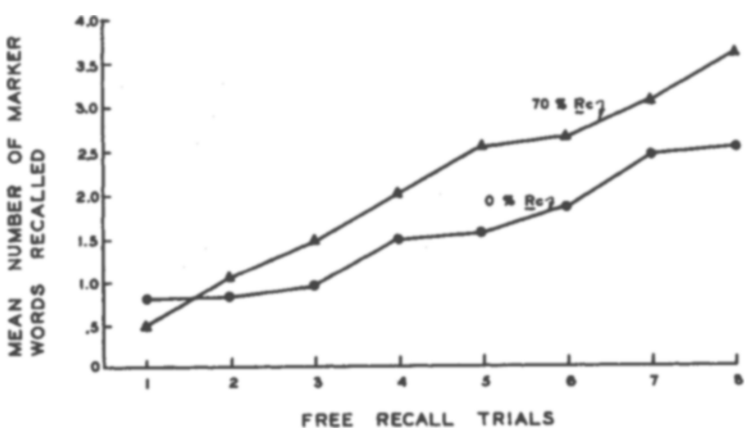

Fig. 2. Free recall of "marker" words as a function of Rc and trials.

are important predictor variables in verbal learning with meaningful stimuli as well.

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NOTE

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Arousal as a function of background factors in psychological experiments[1]

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Two background factors in laboratory research are explored in terms of their effects on the arousal level of Ss. One factor is the laboratory environment as a whole, assessed by comparing arousal levels obtained there to levels obtained during equivalent activities in Ss' homes. Secondly, arousal levels of experienced, paid Ss are compared to those of inexperienced, unpaid Ss. An interaction between these factors unexpectedly partitioned the set of Ss into a low-arousal and a high-arousal group and suggested a reinterpretation of the psychological significance of the factors responsible. Until future research establishes more decisively the relevance of these background factors, auxiliary skin-resistance recording during experiments can help investigators control for these effects.

In designing studies and generalizing from their findings, psychologists necessarily ignore many of the myriad factors which might influence the Ss' behavior in the laboratory experiment. "Irrelevant" characteristics and behaviors of the E, the appearance and atmosphere of the laboratory, and the Ss' motivations, intentions, and previous experience, for example, generally are not considered in research reports. Factors which are excluded from explicit research designs might appropriately be called "background factors." In recent years, a number of investigators have sought to bring these background factors into the foreground by explicitly examining their effects. They have undertaken direct studies of what actually happens in the laboratory environment, and have found that background factors often increase the probability of Type II errors, and worse, systematically bias the data obtained in this environment (Orne, 1962; Rosenthal, 1966; Friedman, 1967; Argyris, 1968).

Rather than dealing with any specific overt behavior, this study is concerned with the relationship between background factors and a "central" concept, arousal. Arousal, often measured by electrodermal recording (van Olst & Orlebeke, 1967), has been found to have a pervasive influence on a wide range of processes and behaviors of interest to the psychologist. With respect to background factors the overall arousal level of the S seems more appropriate than momentary arousal reactions. The Basal Skin Resistance (BSR), which is commonly used for obtaining such a base level, also has the advantage of being relatively simple to record and score as a supplementary measure in any experiment (Kaplan & Hobart, 1964, 1965). This measure has been used successfully in a variety of different settings. For example, it has been shown to be related to reaction time (Elliott, 1964; Andreassi, 1966), perceptual sensitivity (Martin & Edelberg, 1963; Fiss, 1966), and learning and memory (Berry, 1962; Kleinsmith, Kaplan, & Tarte, 1963; Levonian, 1968).

The effects of background factors on behavior vary greatly depending on the kind of behavior measured, so much so that a generally applicable conception of background effects has yet to emerge. Arousal measurement may contribute to a more coherent picture in this area. Arousal is very likely to be influenced by at least some background factors of interest, and has already been shown to be related to a wide variety of processes and behaviors. The particular background factor studied in this experiment was the laboratory environment as a whole. The BSR levels were compared for the same Ss when they were at their campus home and in the laboratory. Virtually identical tasks were being performed in the two settings.

In addition to the "lab-home" dichotomy, differences between two "types" of Ss, "neophytes" and "veterans," were explored. These two types represent the two main ways in which university laboratories obtain their Ss, students fulfilling course requirements and paid volunteers.

SUBJECTS

Sixteen male honors students served as Ss. Eight of these, the "neophytes," had no previous experience as Ss and served in partial fulfillment of a course requirement. The other eight, the "veterans," were volunteer paid Ss who had previously been in at least two experiments, including at least one in our laboratory.

PROCEDURE

Each S participated in two sessions, separated by 1 or 2 days, and both run at the same time of day. The "lab" session occurred in a 7 x 7 ft windowless room, somewhat cluttered with equipment from other ongoing experiments. The "home" session took place wherever S said he usually studied at home, generally at a desk. The S either was alone in his room or was asked not to converse with roommates present during the "home" session. For half of each of the two S groups the "lab" session occurred first, while the other half started with the "home" session.

Each session was divided into two portions. The first 10 min were spent doing timed tasks including paired-associate memorization and recall and a paper-and-pencil visual search task. Parallel forms of these tasks were constructed for the two sessions. The following 30 min were spent doing homework or other reading of S's own choice and at S's own speed. These self-selected activities were restricted only in that each S was asked to read approximately