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ABSTRACT

This report focuses on memory research, using 'interestingness' as a variable in paired-associate (PA) learning and retention. Nine PA lists were constructed from 'interestingness' ratings (high, medium, and low) on both stimulus and response sides, and controls over associative properties of stimulus and response terms. Subjects (162) were assigned to the nine lists and to short-versus long-term (48 hour) retention intervals. No significant interaction between interest and short-versus long-term retention was obtained. Interest had a significant main effect on the response side, with middle levels of response 'interestingness' leading to best retention; a significant interaction was obtained between the stimulus and response terms with retention interval collapsed. It is anticipated that results obtained in this report will help generate new knowledge of the learning and memory processes, particularly their developmental relationship to individual differences and to motivation. (Author/CJ)

SHORT- AND LONG-TERM RETENTION AS A FUNCTION OF VARIATIONS IN STIMULUS AND RESPONSE INTERESTINGNESS

WISCONSIN RESEARCH AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

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SHORT- AND LONG-TERM RETENTION AS A FUNCTION OF VARIATIONS IN STIMULUS AND RESPONSE INTERESTINGNESS

Mary E. Jones and Frank H. Farley

Report from the Motivation and Individual Differences in Learning and Retention Project

Frank H. Farley, Principal Investigator

A paper presented at the annual meeting of the American Educational Research Association, March 2-6, 1970, Minneapolis, Minn.

Wisconsin Research and Development
Center for Cognitive Learning
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This technical report is from the Motivation and Individual Differences in Learning and Retention Project from Program 1. General objectives of the Program are to generate new knowledge about concept learning and cognitive skills, to synthesize existing knowledge, and to develop educational materials suggested by the prior activities. Contributing to these Program objectives, the Learning and Memory Project has the long-term goal of developing a theory of individual differences and motivation. The intermediate objective is to generate new knowledge of the learning and memory processes, particularly their developmental relationship to individual differences and to motivation.

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ABSTRACT

Previous activation and memory research was extended to interestingness as a variable in paired-associate (PA) learning and retention. Nine PA lists were constructed from interestingness ratings using 45 Ss, with three levels of interestingness (high, middle, low) on both stimulus and response sides, and controls over associative properties of stimulus and response terms. Following Underwood's recommendations (1964), control over degree of original learning was obtained by use of a pilot experiment with 45 Ss. The main (retention) study employed 162 Ss randomly assigned to the nine different lists and short- vs. long-term (48 hr.) retention intervals, with the nine lists having varying numbers of learning trials based on the pilot. A significant interaction between interest and short- vs. long-term retention was not obtained. Interest had a significant main effect on the response side, with middle levels of response interestingness leading to best retention; a significant interaction was obtained between the stimulus and response terms with retention interval collapsed.

I
INTRODUCTION

The present study was influenced by two current areas of theory and research. The first area follows the work of Berlyne (1960) concerning the motivation produced by the collative properties of a stimulus, i. e., its degree of novelty, complexity, incongruity, etc. Most of this research has focused on the affective arousal elicited by changes in external stimulation. The second area, concerned with the effects of motivation on acquisition and retention generally, has been based on Walker and Tarte's 1963 revision of the "action decrement" theory. Studies testing the effects of arousal on learning and memory have employed several verbal learning paradigms and various methods of inducing arousal. The design of the present study manipulated the level of affective arousal produced by the stimulus and response terms in a paired-associate (PA) task. Recall measures taken over two time intervals were used to test the effects of degree of arousal on short-term and long-term retention.

Correlational studies of affective arousal in relation to changes in stimulation arose as a result of Berlyne's theoretical formulation pertaining to the informational properties of stimuli as a source of motivation.

> The extent to which an external stimulus is productive of information or of its opposite, uncertainty, is one of the prime determinants of arousal and other attentional processes.... the collative properties of stimuli involve conflict, and... they play a part not only in exploratory behavior but also in fear, aesthetic behavior, production and enjoyment of humour, and thinking [1964, pp. 132-3].

Several studies have obtained affective ratings of visual stimuli along such dimensions as interestingness, pleasingness, and preference (Berlyne, 1963; Day, 1967; Eisenman, 1966, 1967a; Eisenman & Rappaport, 1967). The stimuli used usually consist of random shapes varying along dimensions of the collative properties. The studies support Berlyne's contention that the collative variables are a source of arousal. Other studies have sought correlations between responses to differences in stimuli and subject individual difference variables. Russell Eisenman has done the greatest amount of work in this area; he has found that aesthetic preference can differentiate schizophrenics and normals; schizophrenics prefer less complex polygons and less novel poems whereas normals prefer the opposite (1965a). First-born subjects are more anxious as measured by the Manifest Anxiety Scale (MAS)(Taylor, 1953) and prefer simpler polygons (Eisenman, 1965b). Females prefer more complex polygons than males but there is an interaction between sex and birth-order; first-born males prefer more complexity than later-born males while first-born females prefer less complexity than later-born females (1967b). Later-born females prefer the greatest amount of complexity and later-born males prefer the least; first-borns are intermediate in preference (1967c). A creativity set significantly affected preference choices with subjects choosing the simple or complex polygons in accordance with the kind they were told creative subjects chose (Eisenman, Hannon, & Bernard, 1966). A paper and pencil personality measure of creativity was related to preference for complexity; high creative <u>S</u>s preferred greater complexity, while no correlation was found between IQ and the creativity test or IQ and polygon preference (Eisenman & Robinson, 1967). More creative <u>S</u>s chose more complex figures as preferred and meaningful (Taylor & Eisenman, 1964).

Studies of preferences and choice behavior of infants and young children have also been conducted. Using visual stimuli comprised of random shapes, Hershenson, Munsinger, and Kessen found that newborn infants prefer stimuli of moderate complexity (1965). Among preschoolers, older children preferred high (compared to low) degrees of novelty; boys preferred high novelty, whereas girls preferred high and low degrees of novelty with equal frequency (Mendel, 1965). Harris (1965) found that children's preferences for novelty may persist even when the novel toys and objects are damaged and familiar ones are not. Preschoolers also preferred to look at incongruous stimuli more frequently than at congruous ones (Clapp, 1965). Familiarity has also been found to affect Ss' ratings or choices of stimuli. Endsley (1967) found that preschool children's choices of novel stimuli were an increasing function of the amount of prior exposure to the other stimuli. College students' ratings of interestingness increased with increases in complexity after familiarization of the stimuli (Evans & Day, 1968).

Apart from determining measures of affective arousal elicited by collative variables, researchers following Berlyne's lead have also looked at the effects of other forms of arousal on behaviors such as selective attention and diversive exploration (Berlyne, 1963; Day & Thomas, 1967; Greenberger, Woldman, & Yourshaw, 1967; Day, 1967). The role of arousal or activation in attention was first introduced by Moruzzi and Magoun in 1949 when it was discovered that the diffuse projection system of the brain stem is the system whose activity makes possible organized cortical activity. The system is dependent for its activity upon the level of incoming stimulation. Following this discovery, the importance of arousal level as a motivator of behavior gained favor among psychologists when it was proposed by Hebb (1955) and adopted by Duffy (1957), Berlyne (1960), and others. The generally proposed view is that the organism seeks to maintain an optimal level of arousal and will respond to changes in the environment in such a way as to restore the level of arousal to its optimum. Malmo summarized the development and status of activation theory and research in 1959. At that time he distinguished between the physiological and the behavioral effects of activation. Physiological measures such as heart rate, electroencephelographic (EEG) recordings of desynchronization in the cortex, and respiration were found to have similar curves during sleep and to increase positively with increases in activation level. Behavioral measures, on the other hand, follow an inverted U-shaped curve as activation increases from very low to extremely high levels. Malmo offered the following summary: for activation levels of low, moderate, and high the expected performance levels are low, optimal, and low. The results of Day's (1967) study support this inverted U hypothesis. The proportion of attention responses to high complex material was greater for low anxious Ss under a white-noise (arousal) condition as compared to a no-noise (non-arousal) condition. This trend was reversed for high anxious Ss.

Another issue in the study of arousal, and of arousal-producing materials in particular, is the role of arousal in acquisition and recall following various retention levels. According to Berlyne (1960) the collative variables produce conflict and this conflict leads to increased physiological arousal. Evidence for this relationship was found for the complexity dimension by Day (1965). Galvanic skin response (GSR) and electroencephelographic (EEG) measures changed in an arousal direction with increasing complexity of visual stimuli. Hence, affective arousal associated with the collative properties of the materials should function in the same way as arousal induced by other mechanisms which have been employed in learning and retention tasks (Berlyne, et al., 1965).

There is evidence for the participation of arousal processes during the early phase of learning and for their disappearance when the learned response is firmly implanted (Berlyne, 1964). In classical conditioning paradigms with animals the conditioned stimulus at first produces generalized desynchronization over the cortex as a whole; after learning, desynchronization appears only in the area corresponding to the unconditioned stimulus. The transient phase of widespread desynchronization is a sign of intense and diffuse arousal (Gastaut & Roger, 1960; Jouvet, 1960; John & Killam, 1959 [All authors were cited in Berlyne, 1964.]).

Similar evidence has been obtained from research on human verbal learning. Obrist (1950) and Thompson and Obrist (1964) measured GSR and EEG changes during the serial learning (SL) of nonsense syllables. Mean GSR was higher during learning than during control periods and both GSR and EEG measures indicated a tendency for each item to produce the highest degree of arousal at about the time it was first correctly anticipated. In another SL experiment Obrist (1962) found correct anticipation on different days to be linearly related to heart rate and electrodermographic measures of autonomic activity in two Ss and curvilinearly related to three Ss. Skin conductance measures taken on Ss while they were learning a set of PA items showed that the greatest amount of recall was associated with intermediate conductance levels (Berry, 1962).

Interrelating the concepts of perseverative consolidation, action decrement, and arousal, Walker and Tarte (1963) developed a theory of learning and retention which has generated research into some motivational influences in verbal learning.

(1) The occurrence of any psychological event, such as an effort to learn an item of a paired-associate list, sets up an active, perseverative trace process which persists for a considerable period of time. (2) The perseverative process has two important dynamic characteristics: (a) permanent memory is laid down during this active phase in a gradual fashion; (b) during the active period, there is a degree of temporary inhibition of recall, i.e., action decrement (this negative bias against repetition serves to protect the consolidating trace against disruption). (3) High arousal during the associative process will result in a more intense active trace process. The more intense activity will result in greater ultimate memory but greater temporary inhibition against recall.

According to Weiner (1966) nonassociative factors such as motivation have been relatively neglected in the verbal learning literature while the emphasis has been placed on such associative factors as meaningfulness, frequency of stimulus presentation, degree of learning, etc. Thus, the Walker and Tarte theory has opened the way for an expansion of the type of variables studied under verbal learning paradigms.

Several studies have tended to support the Walker and Tarte hypothesis. A series of experiments has been carried out at the University of Michigan which has provided a methodology for further elaboration and testing of the original results. In a PA task Kleinsmith and Kaplan (1963) varied the level of arousal of eight single words used as stimuli and the time interval used to measure recall. The eight stimulus words, KISS, RAPE, VOMIT, EXAM, DANCE, MONEY, LOVE, SWIM, were paired with eight single digits as response terms. Subjects were given a single learning trial and a single recall trial varying from 2 minutes to 1 week later. Skin resistance measures were taken during learning in order to determine empirically the arousal effects of the stimulus words. The results indicated that learning under low arousal as defined by little change in skin resistance showed greater immediate recall compared to delayed recall [45 minutes and 1 week], whereas items learned under high arousal as indicated by a large skin resistance change demonstrated poor immediate recall but high recall on tests 45 minutes and 1 week later. Kleinsmith and Kaplan (1964) obtained the same results using six low association nonsense syllables as stimulu and six single digits as responses.

Walker and Tarte (1963) replicated the Kleinsmith and Kaplan studies using homogeneous and mixed lists of high- and low-arousal words as stimulus terms and single digits as response terms. Measures of skin resistance were taken during learning. Three groups of Ss under each of the three list conditions (high arousal, low arousal, or mixed) were tested for recall at time intervals of either 2 minutes, 45 minutes, or 1 week after training. Recall scores for numbers associated with low arousal words dropped as a function of time. Recall for high arousal items dropped at 45 minutes and then rose slightly at 1 week. The results were thus in the same direction as those obtained by Kleinsmith and Kaplan (1963; 1964) though not of the same magnitude, especially for immediate recall. The authors offered as a possible explanation for this difference in magnitude the fact that the initial separation between high- and low-arousal items was considerably greater in their materials than in those used in the original studies. Farley (1969) used the stimulus words of the Walker and Tarte (1963) study in a free learning (FL) experiment. His results were similar to those of the above studies for the long-term recall measure; however, the cross-over effect between immediate and long-term recall was not obtained.

Other experiments designed to test these same effects of arousal on learning and retention have employed methods of inducing arousal which are external to the learning task itself. This strategy was adopted in order to preclude the confounding of the effects of general arousal level and the effects of the arousal inherent in the materials used in the learning task. One such method has been the use of delayed auditory feedback (Harper & King, 1967; King, 1963; King & Dodge, 1965; King & Walker, 1965; King & Wolf, 1965). These studies found that prose material practiced under delayed feedback is associated with poorer immediate recall than that learned under control conditions. The result is reversed when the retention test is held 24 hours later. Material practiced under delayed auditory feedback resulted in greater long-term retention, relative to the initial amount of material recalled, in comparison to the control group. These findings are interpreted as indicating that the delayed auditory feedback group showed greater resistance to forgetting over the 24-hour period.

Another method of inducing arousal is the use of differential instructions. Alper (1948) gave "ego-oriented" as opposed to "task-oriented" instructions to two groups of Ss asked to learn a PA list. "Ego-oriented" Ss recalled more new items when tested 1 day after learning than they had recalled on a test given immediately after learning. They also recalled more of the same items that they had recalled on the immediate test than did the "task-oriented" Ss. Batten (1967) combined drugs and "ego-involvement" techniques to induce arousal prior to PA learning. Stimulus terms were words judged to be emotionally neutral and response terms were single digits. Subjects were given a single presentation of the list and tested for recall 2 minutes, 20 minutes, 45 minutes, 1 day, and 1 week later. Though not statistically significant, the results were in the direction of the Klein-Smith and Kaplan (1963) study.

Berlyne and his associates have employed white auditory noise as a means of inducing arousal. With visual patterns as stimulus terms and dysyllabic male first names as response terms, recall was impaired when Ss were administered 72 decibels (dbs.) of white noise during the two training trials and during the test trial 24 hours later (Berlyne, et al., 1965). As it was thought that the results might be attributed in part to the characteristics of the visual patterns used as stimuli, a second experiment was conducted substituting dysyllabic adjectives (e.g., glassy), heterogeneous dysyllabic adjectives (e.g., glassy crucial), and homogeneous dysyllabic adjectives (e.g., crucial crucial) as the stimulus terms. Items were divided into four groups with respect to the time(s) that white noise was presented. White noise was presented either (1) during learning and test trials, (2) during learning or testing but not both (2 groups), (3) neither during learning nor testing. Five different intensities ranging from 35 dbs. to 75 dbs. were used. This experiment showed that on the training day there was significantly less recall for items learned under white noise as compared to items learned with no white noise. On the test trial 1 day later there was better recall of items learned under white noise the day before. No significant effect due to white noise during the test trial was obtained nor was there any significant effect due to variations in white noise intensity.

A third experiment (Berlyne, et al., 1966) tested the effects of the timing of arousal by presenting white noise only during the presentation of the stimulus, during presentation of both the stimulus and the response, during the interval between items, or not at all. The stimulus and response terms were single dysyllabic adjectives and single dysyllabic male first names, respectively. White noise during the presentation of both the stimulus and the response terms on training trials significantly increased recall 1 day later. The presence or absence of white noise after the response did not significantly affect recall on the 24-hour retention measure. There were also no significant differences among the presentation conditions on anticipation during training or on a test trial held immediately after the training trials. Contrary to the previous findings of Berlyne, et al. (1965) and Kleinsmith and Kaplan (1963; 1964) in which arousal had a detrimental effect on immediate recall but enhanced long-term recall relative to the nonarousal condition, no detrimental effect on immediate recall was obtained.

Haveman and Farley (1969) used white noise to manipulate arousal in PA, SL, and FL paradigms. Consonant-vowel-consonant (CVC) nonsense syllable pairs of associative characteristics were used in all three learning procedures. The previous findings that high arousal leads to better long-term retention relative to low arousal was confirmed in the free learning situation only. The interpretation of the results suggested that the effects of arousal are dependent on the nature of the material to be processed and the intensity of arousal.

In a recent article Kaplan, Kaplan, and Sampson (1968) report that several procedural variables have been explored since the initial Kleinsmith and Kaplan study (1963). The former authors cite two studies plus the results of their own as further evidence in support of the detrimental effect of arousal on immediate recall. Levonian (1966) measured the arousal reaction associated with items tested for immediate and long-term recall on the same group of Ss. Arousal following reminisced items (those recalled only on the long-term test) was greater than that associated with forgotten items (those recalled only on the immediate test). Maltzman, Kantor, and Langdon (1966) used a priori groupings of differentially arousing stimuli and a free recall test procedure. They found that high arousal facilitated recall for both immediate and long-term retention conditions. Kaplan, Kaplan, and Sampson attribute the discrepancy in results to the methodological departure from the original paradigm. Their own study (1968) combined the test-retest paradigm used by Levonian and the free recall technique of Maltzman, et al., 1966. Line drawings were used as stimulus terms and words as response terms. GSR measures for reminisced items were greater than those for forgotten items, supporting Levonian and the 1963 and 1964 findings by the Michigan group. An item showing poor immediate recall and good long-term recall was associated with a larger arousal reaction than an item recalled only initially. In the free recall situation pictures were recalled better than words on tests given immediately and after a 30-minute interval. In addition, mean GSR ratings based on items presented as words predicted both word and picture recall. An interpretation was offered in terms of encoding. Pictures may involve double coding, both verbal and imagery, which results in better recall.

In summary, the general findings of the foregoing studies employing arousal-producing stimulus terms, delayed auditory feedback, ego-involvement procedures, drugs, and white noise suggest that arousal facilitates long-term retention. The relationship of arousal and immediate recall has been more difficult to determine. Arousal was found to have a detrimental effect on immediate recall in the studies by Kleinsmith and Kaplan (1963; 1964), Walker and Tarte (1963), Berlyne, et al. (1965), King and Dodge (1965), King and Wolf (1965), Levonian (1966), Kaplan, Kaplan, and Sampson (1968), Farley (1968), Lovejoy and Farley (1969), and Osborne and Farley (1970). On the other hand, no significant inhibitory effect was found by Berlyne, et al. (1966), Alper (1948), Farley (1969), and Maltzman, Kantor, and Langdon (1966).

The present research had three main objectives in its attempt to further investigate the relationship between arousal and recall. One objective was to extend the Kleinsmith and Kaplan (1963; 1964) findings to a paired-associate task employing pictorial stimulus terms and verbal response terms. Variations in level of interest associated with the figures and the words served as the sources of arousal. Secondly, by varying the interest level of both the figures and the words and by adding a medium interest level, the relative effects of arousal on either the stimulus or the response sides of the items in a PA task could be determined. Thus, nine arousal conditions were employed.

The specific hypotheses to be tested were:

(i) Ss learning under the high arousal condition (items composed of high-interest figures and high-interest words—HH) would have significantly better long-term recall than Ss learning under the low arousal condition (low-interest figures and words—LL).

(ii) Ss learning under the LL condition would have significantly better short-term recall than Ss learning under the HH condition.

(iii) The order of recall demonstrated by Ss under the remaining seven conditions would indicate the relative effects of stimulus versus response interest on long-term and short-term retention.

The third and very important objective was to improve upon the design of the former studies by controlling the degree of original learning among the different arousal conditions prior to the retention interval. Underwood (1964) questions the interpretations of many retention studies which have failed to control for the effects of original learning when learning materials have been manipulated prior to the retention interval. If arousal effects are to be interpreted in terms of storage or consolidation processes going on during the retention interval, then performance at the end of the training trials must be controlled across groups.

II
METHOD

DESIGN

A 3 x 3 x 2 fixed effects factorial design was used employing all possible combinations of three levels of PA stimulus term "interestingness" (high, medium, and low), three levels of response term "interestingness" (high, medium, and low), and two retention time intervals (18 seconds and 48 hours).

SUBJECTS

Two hundred fifty-two University of Wisconsin introductory educational psychology students took part in three different aspects of the study. Forty-five Ss were used to obtain interest ratings on 50 words from which the response terms used in the PA task were selected. Another 45 Ss served in a pilot study to determine the number of training trials which should be given Ss under each arousal condition so that original learning would be equated across groups. One hundred sixty-two Ss served in the main study. Half of the Ss made up a short-term retention (STR) group and half a long-term retention (LTR) group. The treatment for both groups was identical except that the STR group was given a test trial 18 seconds after completion of the training trials while the LTR group was given the test trial 48 hours later. Subjects were randomly assigned to each of the two recall groups as well as to each of the nine S-R conditions within each group.

MATERIALS

Both stimulus and response terms were selected so as to control for the effects of novelty and meaningfulness (or association value) while varying the degree of interestingness.

The stimulus terms consisted of polygons constructed by Day according to a method developed by Attneave and Arnoult (1956). Eighteen figures (six 10-sided, six 28-sided, and six 80-sided) were selected from seventy-five rated for association value and interest by Evans and Day[1] (1968). These authors found that after 15 seconds' familiarization with the figures, Ss' ratings of interestingness increased directly as complexity increased. Thus, for familiar shapes, the less complex polygons may be considered of low interest, the middle complex of medium interest, and the most complex of high interest. Association value was measured as the number of associations to a polygon during 15 seconds. The six figures at each interest (or complexity) level were chosen such that the group means for association value were equal (mean = 3.57).

The response terms consisted of words selected from a list rated by Paivio, Yuille, and Madigan (1967) on association value as measured by Noble's m (1952) technique, but using a 30-second test period. The mean association values were equated across groups. The words also appear on the AA frequency list of the Thorndike-Lorge Word Count (1944) and may be considered very familiar words for the general population. To obtain interest ratings, 50 words from the Paivio, et al., list equated on association value and familiarity were presented to Ss on a seven-point scale. Forty-five Ss rated the words along a seven-point scale of "interesting-uninteresting." The order of the rating forms was randomized such that no S rated the words in the same order so as to control for set in responding and for fatigue effects, such as random responding toward the end. Subjects were instructed to work quickly and to give first impressions. Based on the mean interest scores for each word, groups of six words each were selected from the extremes and middle of the dimension to represent high,

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[1] The authors would like to thank Professor H. I. Day for providing a copy of the figures used in the Evans and Day report.

medium, and low interest levels. Group means for the interestingness ratings were high = 1.56, middle = 2.78, and low = 4.09, and for associative ratings from Paivio, et al. (1967), were high = 6.68, middle = 6.52, and low = 6.53.

In the learning task, items were presented in booklets made up of one S-R pair per page. Assignment of response to stimulus terms was random for Ss under each of the nine experimental conditions within the STR and LTR groups. The same randomized pairings were used for both memory conditions. The sequence of items was varied for each trial to control for serial order effects.

PROCEDURE

The anticipation method was used for PA learning. Each S received one familiarization trial on which the six stimuli were presented along for 6 seconds each. During training Trial 1, stimuli and responses were presented together for 6 seconds with the word printed to the right of the figure. On the remaining training trials the stimulus was presented alone for 6 seconds with a blank space on which S was to write the response term if possible. Following the anticipation response the stimulus was shown again for 6 seconds with the response term printed to the right. Instructions were adapted from Runquist (1966, p. 512).

The total number of training trials for each arousal condition was determined from a pilot study such that original learning (the predicted number of items that would be correctly anticipated if an additional training trial, n + 1, were given) was essentially equal across treatments. The pilot study was run using the same design and procedure outlined above. The mean number of correct responses on each trial was used to determine the criterion trial, the first trial on which the mean approximated five (83%) correct anticipations. The number of training trials for a given group was one less than the number of the criterion trial. The number of training trials given Ss under each condition in the main retention study was thus: High-stimulus and high-response (HH)—3 trials; high-stimulus and medium-response (HM)—3 trials; high-stimulus and low-response (HL)—1 trial; medium-stimulus and high-response (MH)—1 trial; medium-stimulus and medium-response (MM)—3 trials; medium-stimulus and low-response (ML)—1 trial; low-stimulus and high-response (LH)—1 trial; low-stimulus and medium-response (LM)—3 trials; low-stimulus and low-response (LL)—1 trial. Following a suggestion by Underwood (1964), this procedure attempted to control the effects of degree of original learning on retention. A criterion of less than 100% correct anticipations was used in order to eliminate over-learning by some groups. Underwood suggests a procedure for projecting a S's expected score on a hypothetical n + 1 learning trial as a means of determining the amount of learning which occurred on the last training trial given. Using the projected scores as original learning measures, one then determines the essential equivalency of the groups and uses loss scores as the dependent retention measure.

To control rehearsal during the 18-second retention interval for the STR group, an interpolated task was employed. Three blank white pages were inserted between the training and the test trials in the booklets. Subjects were instructed to count backwards [on each of the blank pages] beginning with the number "15", writing as many of the numbers as they could until told to turn the page. Six seconds were allowed on each page. Immediately following the third blank page, each stimulus was again presented alone and S was to write the response term if possible. In order to control the activity immediately following learning, the LTR group also performed the number counting task at the end of their training trials. There were no test trials after the task, however. No indication was given that there would be any more to the experiment so that LTR Ss did not know that they would be tested for recall at a later date. Experimenter returned during the scheduled class hour 48 hours later, distributed test booklets, and asked the LTR Ss to try to write the words they had learned the other day. Six seconds were allowed for writing each response term.

ANALYSIS OF DATA

Due to the fact that several of the treatment groups required only one training trial in order for approximately 83% of the items to be correctly anticipated on a hypothetical "next" trial, Underwood's single-entry projection technique could not be used to obtain a predicted original learning measure. However, several other procedures tested by Runquist and Joinson (1968) were found to be almost as reliable as the Underwood procedure. Based on Runquist and Joinson's evaluations of these methods, the "regression" method was chosen as the best of the procedures applicable to the present data. This procedure used a regression equation obtained from the pilot data as the means for predicting the terminal learning scores for the experimental Ss based on the number of items correct on the last training trial given. Thus, the only bias is in the sampling of the pilot and the experimental groups.

Loss scores indicating the predicted n + 1 original learning scores minus the number of items correctly recalled after each of the two retention intervals were the dependent measures used in an analysis of variance.

In addition, an analysis of covariance was performed on the retention scores with the scores on the last training trial used as the covariate. A comparison of this analysis with that performed on the loss scores was deemed necessary because of significant differences among the arousal conditions on the predicted (n + 1) learning measures. Runquist and Johnson state that in a situation where differences at the end of acquisition are a result of sampling error an analysis of covariance can be used to equate the groups. Analysis of the criterion trial scores (n + 1) for the pilot Ss revealed no differences among arousal conditions. Therefore, it is possible that sampling differences existed between pilot and experimental Ss.

III
RESULTS

A 3 x 3 x 2 fixed effects analysis of variance was performed on the memory loss scores obtained by subtracting the number of items correctly recalled on the test trial from the predicted number correct on a hypothetical n + 1 learning trial. Table 1 summarizes the loss scores for each of the 18 groups arising from arousal level-retention interval interactions. Results of the analysis are summarized in Table 2.

The predicted interactions between arousal level of the stimulus and response terms and retention interval was not obtained ($p < .29$). High arousal stimulus and response items (HH) did not result in the poorest STR and best LTR, that is, reminiscence, nor did the LL pairs demonstrate best STR and poorest LTR (Figure 1). Since differential effects for short-term and long-term retention were not obtained with these two extreme arousal conditions (where the degree of arousal/interest is equated for stimulus and response terms), it is not possible to answer the further question of the relative importance of the stimulus-term versus the response-term as the agent of arousal for two different time intervals. This would be done by considering the ordering of the remaining arousal groups relative to HH and LL conditions.

Means of the number of items forgotten over

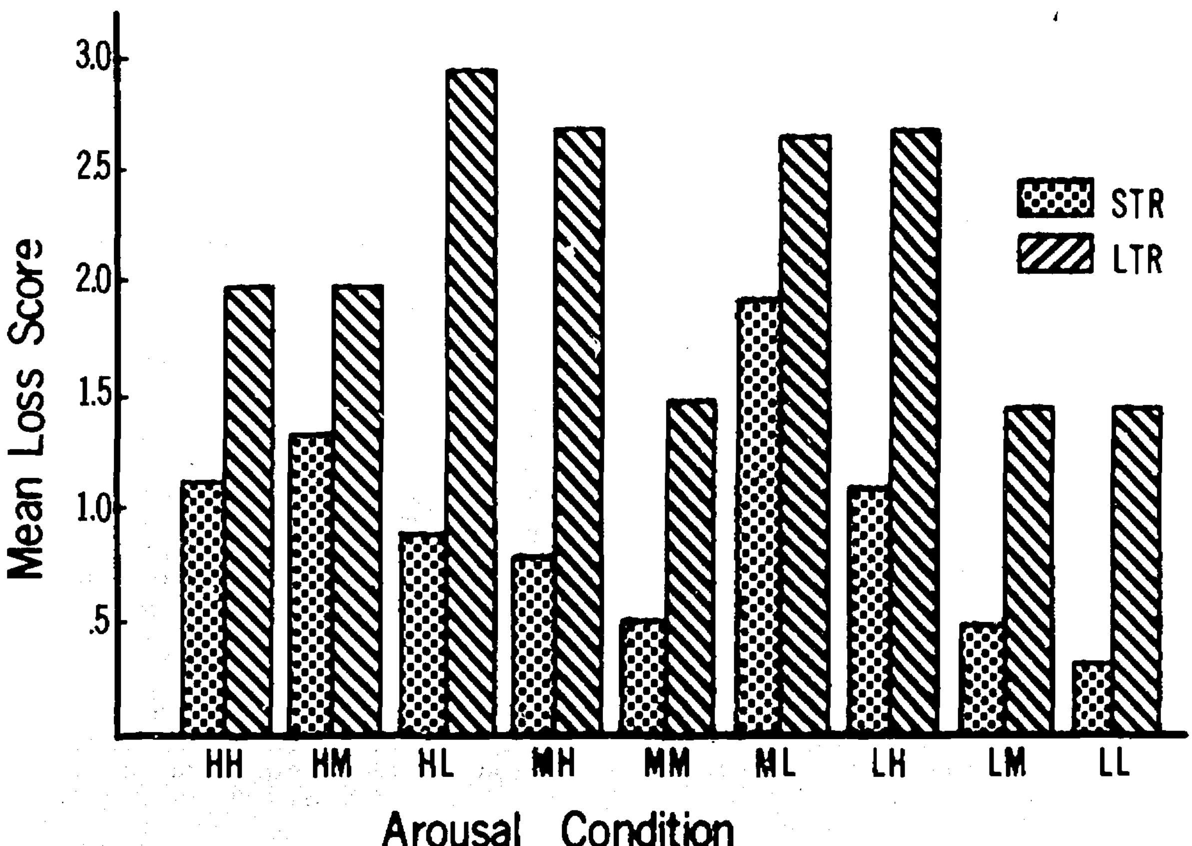

Fig. 1. Short-term and Long-term Memory Loss Under Nine Arousal Conditions

Table 1

Mean Retention Loss Scores of Paired Associates as a Function of Arousal and Recall Interval

	Recall Condition	
Arousal Level	Short-Term	Long-Term
High-High	1.12	1.97
High-Medium	1.43	1.97
High-Low	.84	2.91
Medium-High	.79	2.68
Medium-Medium	.48	1.41
Medium-Low	1.89	2.64
Low-High	1.06	2.66
Low-Medium	.45	1.41
Low-Low	.26	1.40

N = 9 for each group

Table 2

Summary of Analysis of Variance of Retention Loss Scores and Arousal Conditions

Source	SS	df	MS	F
Stimulus Term	8.10	2	4.05	2.85
Response Term	6.26	2	4.45	3.13*
Retention Interval	57.47	1	57.47	40.43***
S x R	19.68	4	4.92	3.46**
S x I	.04	2	.02	.02
R x I	2.14	2	1.52	1.07
S x R x I	7.16	4	1.79	1.26
Error	204.48	144	1.42	
Total	305.33	161		

*$p < .05$
**$p < .01$
***$p < .0001$

48 hours as compared to over 18 seconds reveal greater forgetting over the long-term interval (STR = .92, LTR = 2.12; $p < .0001$; Figure 1).

Differences attributed to degree of interest associated with the response term are statistically significant ($p < .05$). Differences associated with interest on the stimulus side approaches significance at $p < .06$. An interaction effect between stimulus and response terms is also significant ($p < .01$). In order to locate the specific differences contributing to the significant main and interaction effects Scheffé's post-hoc analysis of individual comparisons was performed (Hays, 1963,

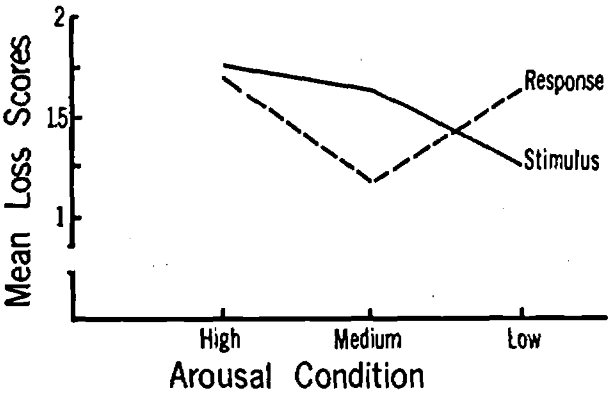

Fig. 2. Memory loss associated with high-, medium-, and low-interest stimulus and response terms in paired associate learning.

p. 484). A significant contrast was obtained between the medium-interest response condition and the average of the high- and low-interest response conditions ($\psi = .50$; $p < .05$). The medium-interest condition demonstrated greater retention (Figure 2). Care must be taken in interpreting this main effect, however, because of the significant S x R interaction. The manner in which stimulus interest level is related to response interest level is shown by the profiles of the simple effects for the response levels at each of the levels of stimulus interest (Figure 3). Inspection of these profiles indicates that the high stimulus-medium response condition (HM) does not demonstrate as good retention as indicated by the significant response-term main effect. The difference is not significant, however, between HM and the average of MM and LM. More marked differences appear among the stimulus interest levels in combination with low response levels. This difference is significant between LL and the average of HL and ML ($\psi = 2.08$; $p < .01$). Medium-low (ML) is also significantly different from the average of LL, LM, and MM ($\psi = 1.37$; $p < .01$). The average of these three demonstrated greater retention relative to the average of the remaining six conditions ($\psi = .94$; $p < .05$).

An analysis of variance performed on the

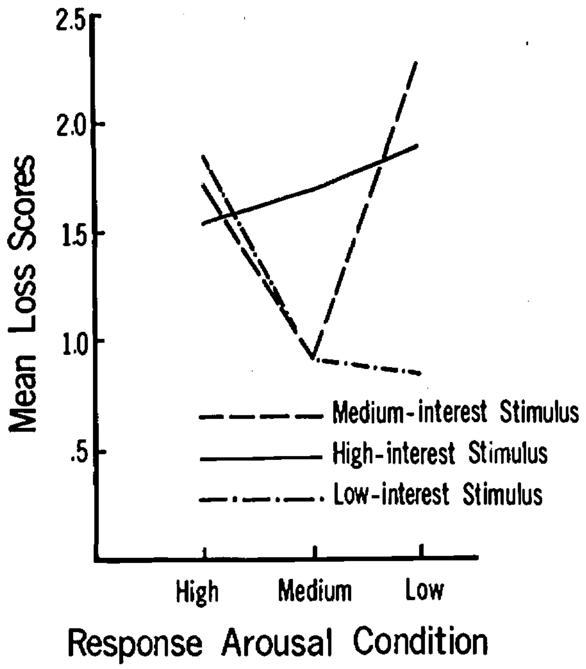

Fig. 3. Profiles of simple main effects for response terms.

Table 4

Summary of Analysis of Variance of Predicted Original Learning Scores and Arousal Conditions

Source	SS	df	MS	F
Stimulus Term	.96	2	.48	.56
Response Term	23.06	2	11.53	13.66*
Retention Interval	.16	1	.08	.09
S x R	3.48	4	.87	1.03
S x I	2.52	2	1.07	1.26
R x I	.30	2	.12	.15
S x R x I	1.28	4	.32	.38
Error	120.96	144	.84	
Total	152.72	161		

*$p < .0001$

Table 3

Mean Predicted Learning Scores of Paired-Associates as a Function of Arousal and Recall Interval

	Recall Condition	
Arousal Level	Short-Term	Long-Term
High-High	4.90	4.64
High-Medium	5.10	4.97
High-Low	4.17	4.24
Medium-High	4.57	4.90
Medium-Medium	5.03	4.97
Medium-Low	3.78	4.31
Low-High	4.50	4.44
Low-Medium	5.56	5.30
Low-Low	4.70	4.18

N = 9 for each group

predicted original learning scores revealed differences among the different arousal conditions. Table 3 summarizes the predicted learning scores for each of the eighteen groups. The analysis is summarized in Table 4. Degree of arousal associated with the response term yielded significant differences in original learning ($p < .0001$). The direction of these differences can be seen in Figure 4.

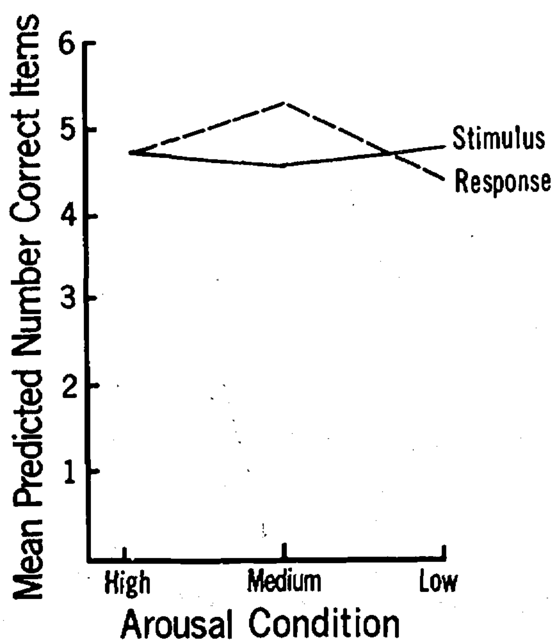

Fig. 4. Degree of original learning associated with high-, medium-, and low-interest stimulus and response terms

Number of items correct on the last training trial served as the covariate in an analysis of covariance. Results are summarized in Table 5 and Figure 5. Differences in retention associated with interest on the response side are no longer statistically significant ($p < .09$) though they are in the same direction as revealed in Figure 2. The stimulus by response interaction remains significant ($p < .02$). The manner in which stimulus interest level is related to response interest level is shown by the profiles of the simple effects for the response levels at each of the levels of stimulus interest (Figure 6). Inspection of these profiles reveals the same patterning as that revealed by the loss score measures based on the predicted original learning scores (compare to Figure 3).

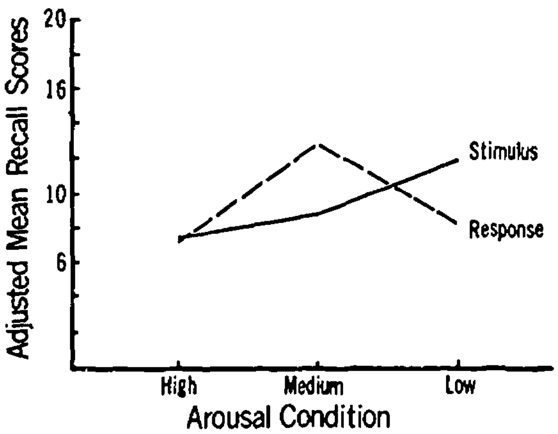

Fig. 5. Adjusted mean recall scores with original learning covaried

Table 5

Summary of Analysis of Covariance of Retention Scores with Last-Trial Learning as Covariate

Source	SS	df	MS	F
Stimulus Term	7.44	2	3.72	2.60
Response Term	6.92	2	3.46	2.41
Retention Interval	59.62	1	59.62	41.65**
S x R	17.28	4	4.32	3.01*
S x I	.12	2	.06	.04
R x I	3.42	2	1.71	1.19
S x R x I	6.20	4	1.55	1.08
Error	204.49	143	1.43	
Total	121.49	160		

*$p < .02$
**$p < .0001$

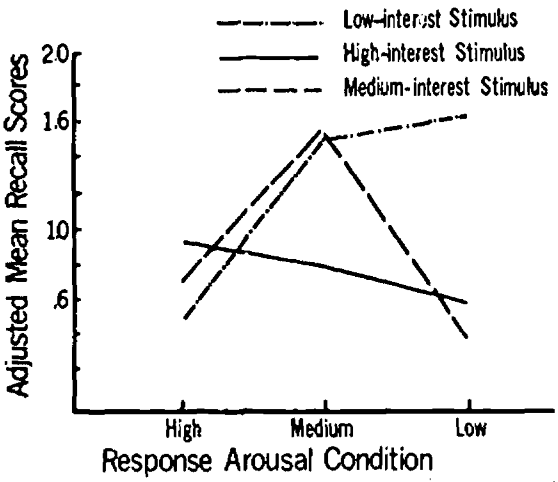

Fig. 6. Profiles of simple main effects for response terms

IV
DISCUSSION

The results of this experiment failed in the purpose of extending the original Walker and Tarte (1963) findings to a paired-associate task in which arousal/interest associated with the stimulus and the response terms of an item was manipulated. Different arousal levels induced by high-, medium-, and low-interest visual stimuli and familiar words had no significant interactive effects on short-term and long-term recall. However, level of interest had a significant main effect associated with the response term and a significant interaction effect between the stimulus and the response terms.

As previously stated, one of the objectives of the present experiment was to improve on the methodology of former studies in which effects due to differences in degree of original learning may have been confounded with possible arousal effects occurring during the processes of consolidation or retrieval of the memory trace. As indicated by the results of analyses of the learning data, the significantly greater retention of the medium-interest response word groups is probably best attributed to the higher degree of learning prior to the retention interval. The reduced significance of the response term main effect obtained when original learning is statistically controlled through an analysis of covariance indicates that the learning differences did indeed affect the retention results. The reduced but still highly significant stimulus by response interaction among the retention means adjusted for differences in original learning suggests, however, that differences in learning is not the only factor contributing to the effect.

The significant differences which account for the over-all interaction effect are interesting and lead to insights into some possible real, though nonsignificant, arousal effects and explanations for the failure of the experiment to reveal such effects if they do in fact exist.

The finding that the LM, MM, and LL groups together differ significantly from both the poorest retention group (ML) and the average of the rest of the arousal conditions can be accounted for in part by the higher learning associated with the LM and MM conditions. However, this explanation does not hold for the LL condition. The significant difference among the stimulus conditions associated with the low-interest response-terms is also due to the greater retention shown by the LL group as compared to the average of the HL and ML groups. An important question, then, is why the LL interest condition (least arousal producing) shows the greatest retention. A second question that might be considered is what trends exist, if any, if the conditions which involved the confounding effects of greater learning are eliminated; that is, HM, MM, and LM (see Figure 4).

The second question will be considered first. Figure 7 shows the relationship of the three levels of stimulus interest to the high and low levels of response interest. The three conditions involving medium-interest response terms have merely been eliminated from Figure 3. The facilitative order of retention shown by five of the six conditions proceeds from conditions of greatest to least arousal. Retention was greatest for the HH condition, followed by MH, LH, HL, and ML (with LH and HL almost equal; loss = 1.86 and 1.88, respectively). This ordering would seem to give some indication as to the relative importance of the stimulus versus the response terms as arousal agents. The high-arousal response pairs show greater retention than the low-arousal pairs for all levels of stimulus interest. Within each response arousal condition, however, the degree of stimulus arousal is important. Retention is facilitated by greater, as opposed to lesser, degrees of stimulus interest. Thus, for these five arousal combinations, it appears that higher degrees of arousal occurring in the response term has the greatest facilitative effect on retention of paired-associate items. However, when arousal level is equated on the response side, stimulus terms having higher arousal properties result in greater retention

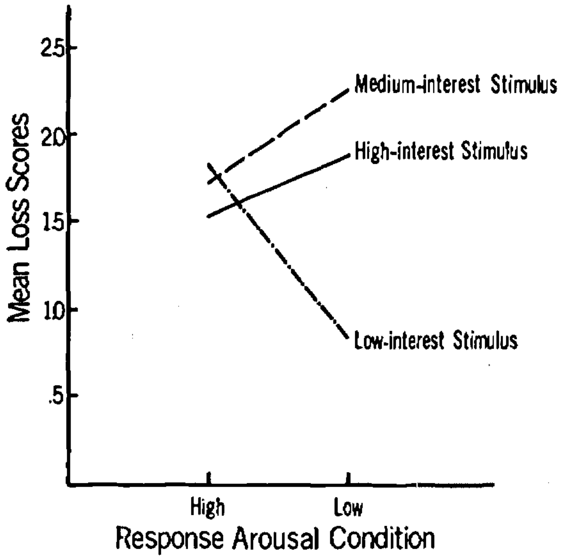

Fig. 7. Profiles of simple main effects for high- and low-interest response terms.

of the learned item. These conclusions may be considered tenuous, however, because of the small absolute differences among the groups. In addition, an alternative explanation might be that arousal level alone is the cause of this particular ordering regardless of the term in which it occurs. It is possible that comparable ranks of arousal level are not actually equal for the stimulus and response terms. Such equality would have to be assured by some objective measure, perhaps physiological, before the relative importance of location can be clearly determined. It must also be remembered that these results are obtained from data collapsed over the two retention intervals. Figure 8 shows the profiles of the effects for the two retention conditions. Though not statistically significant, it can be seen that some complicated interactions are suggested. Real differences may be associated with short-term and long-term retention processes which this experiment failed to demonstrate. Nevertheless, the obtained ranking lends some support to the facilitative role of arousal in the retention of paired-associate items when these items have been equated on degree of learning prior to the retention interval. The suggested effects of arousal relative to the stimulus or the response terms of the items require further testing and confirmation, as well as comparisons involving homogeneous S-R pairs; that is, both S and R items verbal, or both pictorial.

Contradicting the above pattern, the LL condition, presumably the least arousal producing, showed the greatest retention. This surprising result may be explained as being due to confounding factors in both the stimulus and the response terms which outweighed the effects of arousal in their ability to facilitate retention. Inspection seemed to reveal a greater ease of discriminability amongst the six low-interest stimulus figures of lesser complexity. High-interest figures seem to rank second in discriminability due to the ease with which a part of the stimulus-whole can be selected to serve as a functional stimulus for S (Underwood, 1963). Thus, the ease or difficulty in distinguishing the stimuli to be paired may have been confounded with the degree of arousal produced by the stimulus. An ordering of the stimulus figures according to ease of discriminability corresponds to the order of retention for low-interest response word combinations (Figure 7). However, it does not account for the order obtained with high-interest words where the low-interest stimulus group shows poorest rather than best retention; nor does it account for the over-all ranking of the arousal conditions regardless of response-term. This stimulus factor seems to outweigh the interest factor only in the case of low-interest response terms (LL). Two word characteristics which are differentially represented among the three response conditions and which may play a facilitative role in retention are word imagery and concreteness. Ratings of these factors show the particular low-interest words used to be higher in both imagery and concreteness than either the medium or the high-interest words. The order of greater to lesser degrees of imagery corresponds to low, high, and medium interest levels. The order of low to high concreteness corresponds to high, medium, and low interest. As Figure 9 shows, the relative ordering of the response effects associated with the three stimulus conditions does not correspond to the order predicted by either the concreteness or the imagery factors. Only in the case of high-interest stimuli does the ordering hold; however, arousal level also predicts this ordering in this instance. Though stimulus discriminability and response imagery or concreteness cannot be said to have had any over-all effect on the obtained results, they may have been so combined in the LL condition to have a

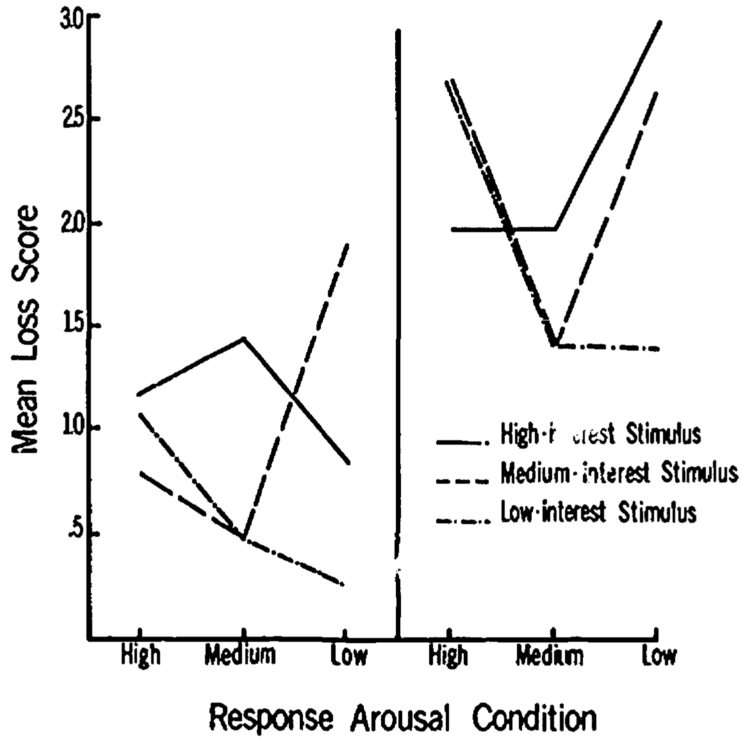

Fig. 8. Profiles of interaction effects for STR and LTR

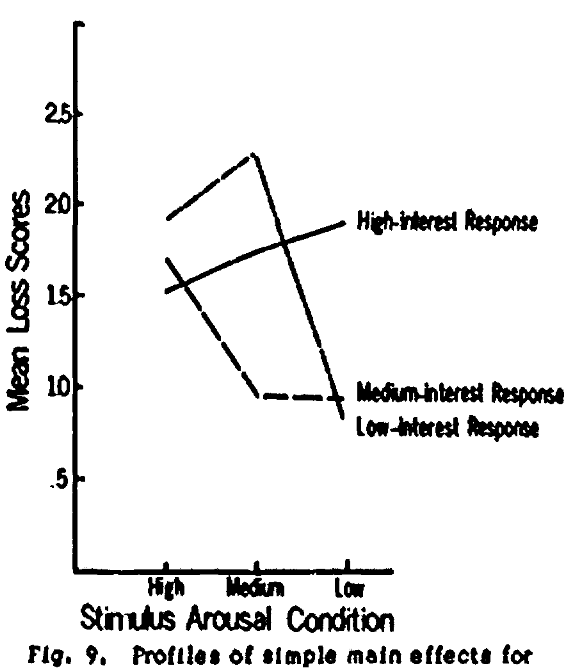

Fig. 9. Profiles of simple main effects for stimulus terms

significant effect. A maximally discriminable stimulus figure combined with words of both high imagery and high concreteness would seem to be a reasonable candidate for maximum retention given the number of facilitating factors alone. Whether or not any of these factors alone can outweigh the effects of arousal can not be clearly determined from this study. It seems, therefore, that the surprisingly good retention shown by the LL condition was due to a combination of other factors which more than compensated for the low arousal produced by such a combination. This strong effect revealed in one group suggests that these confounding factors probably had a similar influence on the retention of the other groups as well. Further experiments must be carried out in order to separate these effects. It is possible that these confounding factors may have in fact depressed a significant real effect of arousal on retention.

Designs for further research should attempt to better control such factors as imagery and concreteness in order to isolate the specific effects of arousal on retention. The problem of obtaining stimulus and response materials equated on all the dimensions which could interact with level of arousal is a formidable one and may not be possible. An alternative procedure might be to systematically vary these factors with arousal to determine the interactions operative in short-term and long-term retention. Farley is currently undertaking such studies.

A second consideration for future research on the relative effects of arousal associated with the stimulus or the response terms would be a comparison of homogeneous S and R terms. An experiment using words, for example, as both stimulus and response terms would eliminate possible effects attributed to the nature of the materials (i.e., possible differences in the encoding processes of pictorial and verbal material). In addition, the same lists might be employed as S-R and R-S pairs for separate groups of subjects to analyze for any effects due to a particular ordering of the S-R pairs. Such studies are underway.

The attempt to control the degree of original learning, among groups learning materials which differ in their arousal-inducing properties, has important implications for basic research concerning the general question of motivation and memory. The theoretical issue remains open as to the nature of the processes underlying memory and the importance of learning in these processes. Experiments employing arousal-inducing procedures which are external to the task itself (i.e., white noise) have been one way of separating the effects of learning and performance and aid in the clarification of memory theory. However, until the present study, the distinction has not been made when tasks using arousal-inducing materials have been employed.

The study of retention as a function of motivational properties of the materials themselves has relevance to education as well as to basic research and theory. Manipulation of the learning materials according to their interest level may be considered analogous to the classroom learning of interesting and uninteresting subject matter. The problem of making the material interesting in order to elicit the students' attention and, hence, to facilitate learning has long been a concern of educators. The possible effects of interest level on long-term retention may make this concern of even greater importance. Since long-term retention is usually the desired goal in the educational process, greater effort might be called for in making learning tasks more interesting than has previously been considered necessary. In addition, since studies in arousal suggest that immediate and long-term test scores may differ with different degrees of arousal during learning, it might be well for teachers to insure the utilization of long-term retention measures.

Though recent research appears to indicate that arousal plays an important part in the learning and memory processes, the effects are not yet confirmed across a wide range of learning tasks. Therefore, the implications for applied learning situations are necessarily speculative. Obviously, research is necessary in situations and with tasks more directly comparable to those of typical classroom learning. One such study has been conducted. Levonian (1967) using continuously presented information (a driver's education film) found that information presented during high autonomic arousal (as indexed by GSR) showed poor short-term retention and enhanced long-term retention. Under the condition of low arousal the reverse appeared to be true.

Although based on paired-associate learning, the task used in the present study reflects an important form of associative learning, particularly where such things as labeling and concept learning in young children are concerned. Thus, the present research paradigm could be extended to young children and have relevance to numerous applied situations.

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