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THE UNIVERSITY OF ALBERTA

THE EFFECTS OF PHONEMIC SIMILARITY ON PAIRED-ASSOCIATE TRANSFER WITH HIGH-MEANINGFUL STIMULI

by

© ANNABEL NESS EVANS

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "The Effects of Phonemic Similarity on Paired-Associate Transfer with High-Meaningful Stimuli", submitted by Annabel Ness Evans in partial fulfilment of the requirements for the degree of Master of Science

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Supervisor

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Date Feb 13, 1974 ....

Abstract

The effect of phonemic similarity on semantic encoding of common words was examined using a paired-associate transfer design. It was hypothesized that in an A'-Br list with the stimulus terms phonemically similar to those in the previous list, Ss who were previously primed to attend only to meaning would suffer phonemic interference only if they were unable to ignore the phonemic attributes of words or avoid activating the phonemic code. Subjects learned three lists. One group was encouraged to attend only to meaning by making the second list stimuli synonomous to and paired with identical responses as those in the first list. Another group was primed to attend to the phonemic attribute in an identical manner.

In Experiment I, semantic priming was evident. Third list performance of this group reflected no negative transfer due to phonemic similarity in the initial performance measures. An analysis of intrusion errors however, found abundant intrusions due to phonemic confusions in the semantically primed group. The phonemically primed group demonstrated marked positive transfer on the second list and showed negative transfer on the third repaired list. Experiment II was designed to further investigate these effects. This experiment partially replicated the first experiment with some modifications in design. Semantic priming was not as effective in this experiment as in Experiment I. The semantically primed group however, demonstrated reliable interference in third list performance. The results were discussed in terms of the inability of Ss to selectively code semantic attributes of words when similarity in the phonemic dimension is present.

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Introduction

The purpose of this research was to investigate the function of the phonemic attribute in paired-associate learning of common words. More specifically, the problem was to determine if encoding of this attribute is a necessary condition for learning of these kinds of materials, even when it's activation may produce interference. Common words are semantically rich or highly meaningful and thus, would seem to be easily encoded, since the semantic attribute should provide enough information to usefully distinguish between different items. The phonemic attribute with these kinds of materials would seem to provide redundant information in the case where the items are semantically dissimilar. Assuming that selective coding of attributes occurs, it follows that when semantically dissimilar words are stimuli, phonemic similarity should logically not interfere with semantic encoding and thus, learning. However, it appears that phonemic information is not ignored and indeed does disrupt performance in many cases, even when common words provide the learning materials. This suggests that learning involves encoding of both semantic and phonemic attributes. The critical question here, is whether encoding of the phonemic attribute is necessarily involved in any learning situation or alternatively, whether it's activation can be prevented by <u>S</u>s when it is not viable. If attending only to the meaning of stimuli provides efficient discrimination and ease of learning and if <u>S</u>s are indeed attending only to meaning, can they continue to do so when possible interference due to phonemic similarity, is introduced. If phonemic processing occurs even in the event of a proven successful and available semantic code, phonemic similarity should produce interference. By providing a strong set for Ss to code semantically and then introducing possible phonemic interference, the obligatory nature of the phonemic code should come to light. Phonemic similarity effects have been demonstrated in several learning situations. Since this research is primarily concerned with the function of the phonemic attribute in interference, a review of what is known about its effects in memory will be provided. A brief discussion of the theoretical explanations for interference effects will be presented in the following section. The design used in this research and its parameters will be explained followed by a discussion of the rationale of the present investigation.

Phonemic similarity. Shulman (1971) has extensively reviewed the literature investigating similarity effects in memory and thus, only a brief discussion is presented here.

The detrimental effect of phonemic and acoustic similarity on performance has been demonstrated in several Short-Term-Memory (STM) studies (Wickelgren, 1966; Conrad, 1959; Hintzman, 1965; 1967). This effect is typically shown by the confusion errors Ss tend to make in these situations; Ss tend to confuse those items which are similar in sound and visual appearance. Since these effects appear to be greater with short retention intervals, this evidence has been interpreted to suggest that processing in STM is phonemic while processing in Long-Term-Memory (LTM) is semantic in nature. This interpretation has led to studies attempting to demonstrate semantic effects in STM paradigms. Although most of these studies have found a relatively small effect (Conrad, 1965; Baddeley, 1966), a study by Schwartz (1966) provided some evidence for the influence of conceptual similarity in STM. Since there seems to be some reason to accept the possible influence of semantic similarity in STM, the salience of phonemic similarity in LTM would further aid in resolving the STM-LTM distinction. Phonemic effects in delayed recall have been investigated by Baddeley (1968) within the framework of the Peterson-Peterson paradigm. Forgetting rates for phonemically similar and dissimilar words, were compared. Shorter lists were used for the experimental condition in order to control for the detrimental effects of phonemic similarity on immediate recall. Forgetting rates were equal but the difference in list length precludes an adequate assessment of the results. A more useful method was applied by Bregman (1968) to investiage forgetting rates for words with rhyme, graphic or conceptual cues. After presentation of strings of words, a probe was presented consisting of one of these cues. Recall at retention inter als of three to 288 seconds found similar rates of forgetting for all of these cues. Thus, phonemically related probes were as effective as conceptual and graphic up to 4.8 minutes, providing strong evidence for the influence of phonemic similarity in LTM. It appears then, that the justification for considering LTM and STM to be completely independent is not yet clear. Whether this distinction is a necessary one, is a question still to be resolved. Shulman (1971) to this same point, proposed an alternative to the STM-LTM explanation of similarity effects. He suggested encoding and rehearsal to be time-dependent processes which may be time-shared and traded off with one another. Assuming rehearsal to be a useful means of maximizing retention, and phonemic encoding to be achieved more rapidly than semantic encoding, it would seem clear that the use of phonemic encoding will be a useful means of maximizing rehearsal and thus, retention. Furthermore, Shulman proposed encoding of semantic attributes to be a function of the task demands. Hence, whenever semantic encoding is not demanded, encoding will be phonemic, resulting in greater rehearsal time and thus, superior performance.

Phonemic similarity has also been studied using paired-associate techniques. Bruce and Murdock (1968) found proactive (that due to previous learning), but not retroactive (that due to subsequent learning) interference due to phonemic similarity. Most of the research studying phonemic effects in LTM used words as stimulus and/or response materials. This practice maximizes the opportunity for semantic encoding and thus, perhaps deflates the effect of phonemic similarity. For example, Bruce and Crowley (1969) using semantically unrelated word pairs at recall intervals of 10 minutes, 24 hours and one week, found no effect of phonemic similarity in performance. These same investigators however, did obtain a significant facilitative effect of phonemic similarity in a later study (Bruce and Crowley, 1970). Free recall of sets of four phonemically or semantically related words followed a distractor task. The phonemically related words were better recalled than the unrelated words but more poorly recalled than the semantically related sets, suggesting that the phonemic attribute may be used by Ss in LTM but it is not as efficient as the semantic one.

The specific conditions in which each attribute becomes effective have yet to be determined. In some cases, the learning task itself may affect to which attributes S attends. The particular stimulus materials and the biases, attitudes and preconceptions of the S may well be an integral part of the coding process. Adams, Thorsheim and McIntyre (1969) provided evidence that S may even have conscious control over his encoding strategies to some degree. Phonemic similarity of nonsense items produced a detrimental effect on their recall at delayed retention intervals. This effect then disappeared when instructions to find natural language mediators were given. It seems, then that encoding strategies may be controlled by several varying factors.

Although Bruce and Crowley's (1970) study appeared to demonstrate that phonemic information may aid in delayed recall, results to the contrary are also evident in the literature. Wickens, Ory and Graf (1970) reported a series of six experiments dealing with semantic and phonemic similarity in LTM. Their results indicated that both semantic and phonemic attributes of words are encoded in LTM, but these two dimensions do not function in the same way in transfer. While semantic encoding led to both positive and negative transfer effects, phonemic encoding produced negative but not positive transfer effects. In other words, phonemic information is operative in that it disrupts performance in an interference situation. However, it does not serve to facilitate learning in a positive transfer paradigm. This result suggests that not only can Ss not use the phonemic attribute to aid in long term learning but in addition, they cannot avoid it when it serves to interfere in learning. In some cases however, it seems that Ss can avoid the disruptive effects of phonemic similarity in delayed recall (e.g., Bruce and Crowley, 1969). Adams et al. (1969) work in this area found that interference may be reduced if Ss are instructed to use a certain strategy when learning the list. Thus, the nature of the phonemic attribute is still not clear. Its function in delayed recall seems usually to be disruptive but in certain cases this interference may be avoided.

Phonemic and semantic similarity appear to be interfering factors in several memory tasks. Subjects seem to use the phonemic attribute, whether it be acoustic, articulatory, formal or other, for encoding in the STM situation since phonemic processing occurs quite rapidly. Semantic cues are more likely to be effective with longer retention intervals and encoding in this dimension may require more time to become established. While semantic encoding appears to be dominant in LTM, phonemic similarity may well interfere with this process, although the phonemic attribute itself does not usually provide much aid when it is a potentially useful cue for recall.

Interference and interference reduction. Why interference due to similarity occurs and how it is reduced in order for S to master learning materials is a critical question in the area of encoding in memory. A f ew of the classical and contemporary views of this phenom on is presented here.

The term interference has been used to describe and explain why performance decrements result from learning other tasks or materials. Classic interference theory employed the concept of response competition to explain interference effects. If an association exists between stimulus 'A' and response 'B', the learning of a new assocation 'A-C', will interfere with the prior association at recall, since the responses 'B' and 'C' will compete with each other when 'A' is presented (McGeoch, 1942). This in brief, is response competition. Since then, the response competition theory has been modified to include the concepts of unlearning and spontaneous recovery but essentially, the hypothesis remains the same. Gibson (1940) provided another view of interference effects with her notion of stimulus generalization. Similar stimuli were seen to be generlized in early learning, such that similar stimuli may evoke each others responses. Correct responding was seen to occur when Ss were able, through differential reinforcement, to differentiate between stimuli. Traditional response competition theory however, conceptualized learning to occur as incorrect associations were weakened and thus, forgotten through non-reinforcement. This view differed from Gibson in that her theory did not assume incorrect responses to be forgotten, but rather that stimuli became more differentiated or discriminable through reinforcement of correct responses. This notion of stimulus generalization was elaborated on by several investigators (Underwood, 1964; Runquist, 1972), with the introduction of the concept of the coding response. The coding response is not considered to be the actual encoding itself, but rather the way S encodes a particular stimulus. Code confusion or errors in encoding was employed by Runquist to explain interference due to similarity. The distinction between response competition used in associative models and code confusion is seen in the site of the actual interference. Response competition assumes that a stimulus is associated or linked with more than one response. With code confusion however, the associations are not confused but rather, the actual encoding responses are responsible for interference. In other words, S encodes the 'A' stimulus as if it were 'C' and thus, presentation of either 'A' or 'C' stimuli may evoke the same response; that associated with 'C'. The existence of these two kinds of interference, associative and code confusion, has been supported in several studies (Runquist, 1973).

Two kinds of mechanisms appear to operate to produce interference in learning. An associative process serves to confuse associations between stimuli and responses. The concept of response competition is employed to explain this kind of interference. Responses are seen to compete with each other when the stimulus is presented for recall. This kind of interference is presumed to be reduced by differential reinforcement of correct responses and non-reinforcement of incorrect responses, such that the incorrect associations become weakened. The second mechanism that of the encoding response, may result in decreased performance if duplicate or incorrect encodings of the stimuli occur during learning or recall of the response. Gibson's theory of differentiation of stimuli through reinforcement of correct responses has provided the mechanism for reduction of interference due to code confusion. When similarity is present S must somehow differentiate between stimuli in order to reduce interference. In other words, S must learn to establish discriminative codes to learn the material. When nonsense or unpronouncable stimuli serve as learning materials, it is generally agreed that discriminative coding is based on letter selection (Runquist, 1970; Postman and Greenbloom, 1967). When the structure of the list becomes complex and thus, selection is more difficult, interference will increase (Runquist, 1970; 1971). Although less research has been concerned with meaningful materials, such as words, it is usually thought that discriminative coding will be based on meaning (Runquist, 1970; 1971). Discriminative coding then, assumes that the establishment of a stable and discriminative code is the necessary condition for learning. This is accomplished by locating some aspect of the stimulus which will usefully distinguish it from all others in the list. Martin (1968) developed this notion further by suggesting that once a code has been established, S may furthermore switch encodings if the previous code no longer provides discrimination among stimuli. He proposed that S may encode different aspects of the stimulus term as functional cues for response recall, depending upon the demands of the task. For example, if S established a useful and discriminative code for a stimulus during an earlier part of the task and later finds that code no longer is discriminating, he may then establish a new code by using a different attribute of that stimulus. In other words, S may recode a stimulus in order to avoid interference which may result from it's previous encoding. Williams and Underwood (1970) investigated Martin's recoding theory, employing a transfer paradigm to manipulate functional encodings. They found transfer to be uninfluenced by their manipulations. This lack of support for recoding has been further substantiated by Goggin and Martin (1970), who discovered that not only is it not a natural response in an interference condition for S to recode, as Martin suggested, but rather S prefers to retain the already established functional cue. Carlson (1972) in an effort to force stimulus recoding of words along a semantic dimension by making easily available the potential alternate code, found Ss were simply unable to do this. It was concluded that in most cases, recoding is a difficult if not impossible feat for S to perform. It appears then that the flexibility of encoding that has been attributed to human learners may well not exist. Subjects, when faced with interference may continue to use the original code rather than attempt to switch to a more viable code. Perhaps recoding a stimulus which previously was satisfactorally encoded, may well be more difficult and interfere more severely in learning than does experimenter induced interference. Richardson (1972) suggested just this, by pointing out that using the same functional stimulus for both lists may not in general, interfere more with second list learning than would a search for a different set of functional stimuli.

It seems then the first step in learning is to establish a useful and discriminative code for each item in the to-be-learned list. With nonsense or unpronuncable stimuli, S may achieve this by selecting an unique letter of each stimulus for response recall, when similarity between stimuli is present. Thus, in this case, a strategy is employed by the learner. With meaningful words as stimuli, letter selection seems to be a difficult strategy since words are assumed to be encoded as entire units such that the meaning of each is processed. Why phonemic similarity between words then, should serve to interfere in learning, is not clear. Any semantic code should logically eliminate interference if ample time is provided for its establishment. Since phonemic similarity does however, disrupt learning of these kinds of materials, it may be that the phonemic attribute must be attended to and processed even when it provides unnecessary interference (e.g., Runquist, 1971; Nelson and Brooks, 1973). The present investigation was concerned with this possible obligatory nature of phonemic encoding with meaningful materials. The transfer paradigm was selected for the study of this problem. This technique was chosen because it provides an effective means of manipulating similarity variables and an effective means of attempting to manipulate encoding strategies. Since the transfer paradigm is complex, a brief review of the laws and postulates of transfer is presented in the following section.

Transfer of training. Transfer of training is defined as the influence of previous experience on current performance. Bruce (1933), one of the pioneers in this area, found that learning to make a new response to an old stimulus resulted in a negative or inhibitory effect on learning. This paradigm is denoted A-B, A-C, where the first and second letters of the respective pairs refer to nominal stimulus and response. He discovered a marked facilitation or positive effect when learning to make an old response to a new stimulus, A-B, C-B, and slight facilitation in a control group which learned both new responses and stimuli, A-B, C-D. Osgood (1949) elaborated on Bruce's findings and presented several propositions about the nature of transfer. He suggested that (1) facilitation in learning increases as similarity between stimuli increases when responses are identical, (2) interference decreases as similarity between responses increases when stimuli are identical, and (3) interference increases as similarity between stimuli increases when stimuli and responses are varied simultaneously. Osgood then, generalized Bruce's (1933) findings to include the situation of similarity between stimuli or responses. Osgood further postulated a transfer surface or model which predicted the effects of similarity manipulations on performance.

There are several paradigms used in transfer experiments. The transfer technique allows manipulation of both response similarity and stimulus similarity. Some of the most typical paradigms used, include the facilitative A-B, A'-B and the disruptive A-B, A'-Br models. The former uses identical responses and similar stimuli which results in positive transfer from the first to the second list (Uehling and Underwood, 1972). The interference paradigm where stimuli are similar and responses are identical but repaired on the second list, produces marked negative effects, since the formerly correct responses are still present but they are no longer appropriately paired. In this case, what was learned on the first list serves to interfere with learning of the second list. Thus, if S attempts to use any of the information about stimulus-response pairings of the first list, on second list learning, performance will be hindered. This paradigm then, provides an effective means of studying how S encoded stimuli on the first list. Performance on the second list may give direct evidence of this, if the encoding strategy itself is transferred from the first list. In this way then, the actual encodings employed in the first list may be discovered.

Statement of problem. It is clear then that S may use different strategies or encodings in order to master learning in many situations. When faced with unpronouncable trigrams, for example, S may select a letter from the stimulus and attempt to link it with the response. Lists consisting of highly meaningful materials however, do not lend themselves to this kind of selective processing since the stimulus is presumably coded as a meaningful and integrated unit. It seems safe to assume that when materials such as common words act as stimuli, S attends to their semantic attributes such that the meaning of the word is processed or encoded. If selective encoding of semantic attributes occurs, similarity in any dimension but semantic, should not affect learning. When stimulus similarity is phonemic for example, any semantic code should eliminate interference. The literature however, has shown this not to be the case. Several theorists have attempted to explain the persistence of phonemic interference with meaningful materials, but the reasons for this persistence are still not clear.

The nature of encoding and the effects of similarity in memory continue to be problems of critical relevance in the area of learning and memory. It appears that semantic encoding does not necessarily cause phonemic information to be ignored. One critical question is whether S can avoid activating certain codes when they interfere with learning. The research reported here, was concerned with this question. Paired-associate lists were designed in such a way as to encourage a particular encoding strategy on the part of S. A transfer paradigm was employed. One group was encouraged to code on the semantic attribute by learning two lists in which synonyms to the stimuli in the first list were used for second list learning, with identical responses. Another group was encouraged to code on the phonemic attribute by using rhymes to the stimuli in the first list for second list learning. Both groups then learned a third list which had stimuli which rhymed with those in the second list but the responses were paired innappropriately to the rhymes. This creates an A-B, A'-Br interference model. The semantically primed group should suffer interference however, only if it is unable to avoid activating the phonemic code. If in fact, this group could continue to use the semantic attributes in learning the third list, the phonemic similarity would not be expected to produce any decrements in learning. If however, the phonemic attribute is an obligatory one, the semantically primed group would be expected to suffer less interference than the phonemically primed group but about as much interference as a control group which had not been primed. It should be noted here that in the present research, phonemic similarity is confounded to some degree with formal similarity, and thus conclusions about the phonemic attribute are restricted to also include the possible effect of the presence of formal cues. This confounding was not considered to be critical since the primary interest here, is whether Ss are able to avoid interfering attributes and use only semantic cues in encoding.

In Exp. I, Ss learned three lists. Subjects in one condition were set to code semantically by making meaning a relevant way of learning the second list. The A-B, A'-B, a facilitative model, where Ss learn to make the same response to a similar stimulus was used, with synonyms comprising the stimulus materials. A second group was treated in the same way with phonemic information the viable attribute; rhyming stimuli paired with identical responses. Both groups had a phonemically similar but repaired third list; A-B, A'-Br, interference model. Two control groups were used to evaluate positive and negative transfer. Both the semantically primed and the phonemically primed groups were expected to show facilitation in second list learning when compared to a control group which learned an unrelated second list. The phonemically primed group was expected to show phonemic interference effects on the repaired third list when compared to a group which learned an unrelated third list. Expectations for the semantically primed group conformed to one of two hypotheses: (1) interference if phonemic encoding was activated or (2) no interference if Ss were able to continue to use the semantic code on third list learning.

Experiment I

Method

Design and materials. Subjects were required to learn to press one of six buttons arranged in a linear array when one of six two-syllable adjectives was presented on a visual display. Each S performed this task with three sets of six stimuli selected and assigned to response buttons to fit one of four conditions.

The four groups are defined as follows: SEMANTIC A-B, A'-B, A"-Br; where A and A' are related semantically and A' and A" are related phonemically: PHONEMIC A-B, A'-B, A"-Br; where A, A' and A" are related phonemically: PHONEMIC CONTROL C-B, A-B, A'-Br; where A and A' are related phonemically: SEMANTIC CONTROL A-B, A'-B, C-B; where A and A' are semantically related. The four experimental paradigms are illustrated in Figure 1 for clarification (see lists in Appendix A). For all conditions the third list was identical. The SEMANTIC, PHONEMIC and PHONEMIC CONTROL groups used identical second lists where phonemic similarity was high with respect to the repaired third list e.g., List 2 - CRAZY; List 3 - LAZY repaired. The SEMANTIC and SEMANTIC CONTROL groups learned a first list in which each stimulus had a semantically related counter part in List 2 e.g., List 1 - INSANE; List 2 - CRAZY. These pairs were taken from Hilgard (1951) and had an average similarity rating of > 2.45. The PHONEMIC condition used first list stimuli which were phonemically similar to both the second and the repaired third list items

Figure 1

Experimental Paradigm for Experiment I

	List 1 to List 2	List 2 to List 3
SEMANTIC	S	P R
PHONEMIC	P	P R
PHONEMIC CONTROL	X	P R
SEMANTIC CONTROL	S	X

R = repaired responses

X = unrelated stimuli

S = semantically related stimuli

P = phonemically related stimuli

e.g., List 1 - HAZY; List 2 - CRAZY; List 3 - LAZY repaired. In the PHONEMIC CONTROL condition, an unrelated or X list was learned first and in the SEMANTIC CONTROL group, an unrelated list was learned last.

Traditionally an A-B, C-B or in this case an A-B, C-B, E-F paradigm is used to provide the baseline for transfer. However, the interest here lies in the relative effects in transfer of varying similarity and not in the amount of transfer as such. Thus, the designs employed would seem to be appropriate with respect to the areas of interest.

Apparatus and procedure. Subjects were seated in a booth within which was a sloping response panel containing the six buttons. Directly above each button was a small light. Located on the front wall of the booth was a 3 x 5 in screen on which the adjectives were presented. A system of relays controlled by a punched paper drive selected stimuli in a random fashion. A cam driven by a synchronous motor controlled presentation rate. Outside the booth, hidden from S, was another panel containing two linear arrays of lights; one array depicted the displayed stimulus and the other depicted the Ss response. Subjects were run singly with E recording responses on prepared data sheets.

All learning was by the study-test method at a 2 sec rate. One 2 sec blank separated the study and test sequences. Ten orders of presentation were used.

Subjects were run to a criterion of 2 perfect trials in a row and at least 5 trials on all lists. After the data collection was completed, it was found that Ss reaching criterion prior to 5 trials on List 1, was not differential between groups. Approximately one-half minute separated the lists. Subjects were issued standard Paired-Associate instructions modified for the task. No information concerning relationships between lists was provided.

Subjects. Subjects were 80 introductory psychology students who participated as an option for course credit. Subjects were assigned to conditions as they appeared in the laboratory, according to a scheme which randomized order of conditions within blocks containing each condition once.

Results

The data were initially analyzed using One-Way Analyses of Variance of each list and will be discussed separately. Mean number of errors was the primary performance measure. Several secondary measures were taken and are reported when appropriate. These secondary measures were mean errors to first correct, mean trials to criterion and mean errors on Trials 1 and 2. The results of all of these measures are presented in Table 1. The complete Analyses of Variance are presented in Appendix C.

Analyses of List 1 performance. No difference in first list performance were obtained in any of the performance measures with the largest $F(3,76) = 2.61$, $p > .05$, for mean errors on the first two trials.

Analyses of List 2 performance. All measures showed significantly different performance between groups with $F(3,76) = 4.17$, $p < .01$, for mean errors. Specific comparisons with the PC group were

Table 1

Results for Experiment I

	Cond	List 1	List 2	List 3
Mean Errors to Criterion	SC	17.95	6.15	7.70
	S	13.50	6.40	7.70
	PC	21.65	11.15	9.60
	P	17.30	3.15	12.30
Mean Errors on Trials 1 & 2	SC	6.75	3.50	4.90
	S	5.35	4.05	5.10
	PC	7.10	4.75	5.30
	P	5.45	1.85	6.45
Mean Trials to Criterion	SC	7.70	3.05	3.90
	S	6.55	3.70	3.75
	PC	9.05	5.10	5.20
	P	7.95	2.20	5.55
Mean Errors to First Correct	SC	8.95	3.05	4.80
	S	5.35	4.10	5.25
	PC	7.70	1.55	7.95
	P	9.35	5.15	5.10

made to assess transfer effects. Dunnetts Test found the P group ($p < .05$) and the SC group ($p < .05$) demonstrating superior performance on this list. The S groups approached significant facilitation ($p < .10$). Thus, expectations concerning facilitation were supported in the P and SC groups and to some degree in the S condition. The S and SC groups were identical in principle and thus, the greater facilitation seen in the SC group must be attributed to list differences.

Analyses of List 3 performance. List 3 performance was significantly different between groups with $F(3,76) = 2.89$, $p < .05$, for mean errors. Specific comparisons with the SC group were made to assess interference effects. Dunnetts Test found the P group performing poorest on most measures ($p < .05$), as was expected. No significant differences were obtained between the S, SC and PC groups.

Discussion

The prediction of positive transfer on the second list of all except the PC condition, was adequately supported. The PC group performed consistently poorest with semantic facilitation seen in the SC and S groups and phonemic facilitation seen in the P group. Performance on List 3 showed marked negative transfer in the P group compared to the SC control. The S, SC and PC groups did not differ significantly in performance on this list. However, a definite trend appeared, as can be seen in Fig. 2 and 3. The PC group performed more poorly than either of the S and SC groups which appeared equivalent in performance. This result conformed to Hypothesis 2 in the introduction. This effect however, was not statistically reliable.

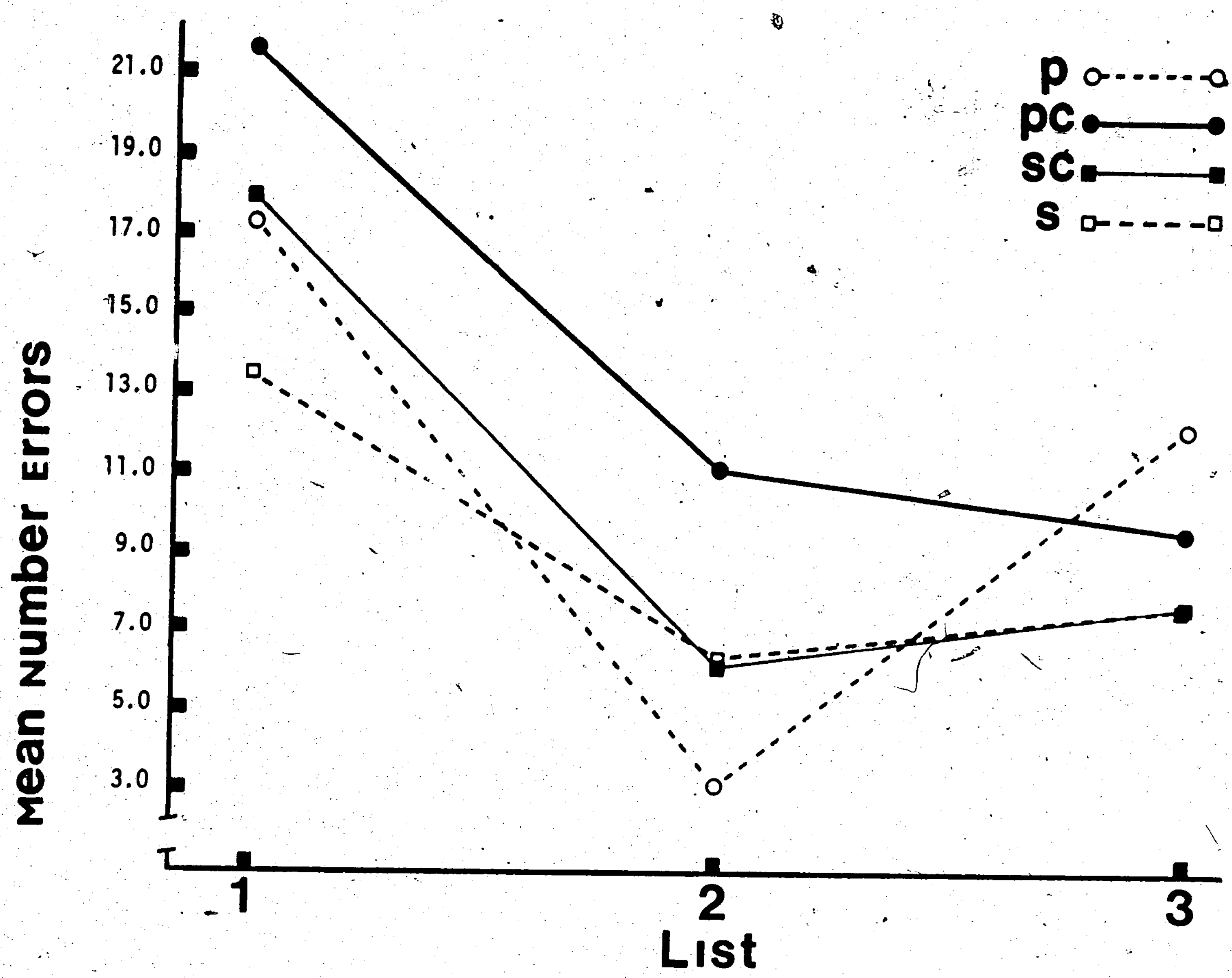

Figure 2: Mean number of errors per list for Experiment I.

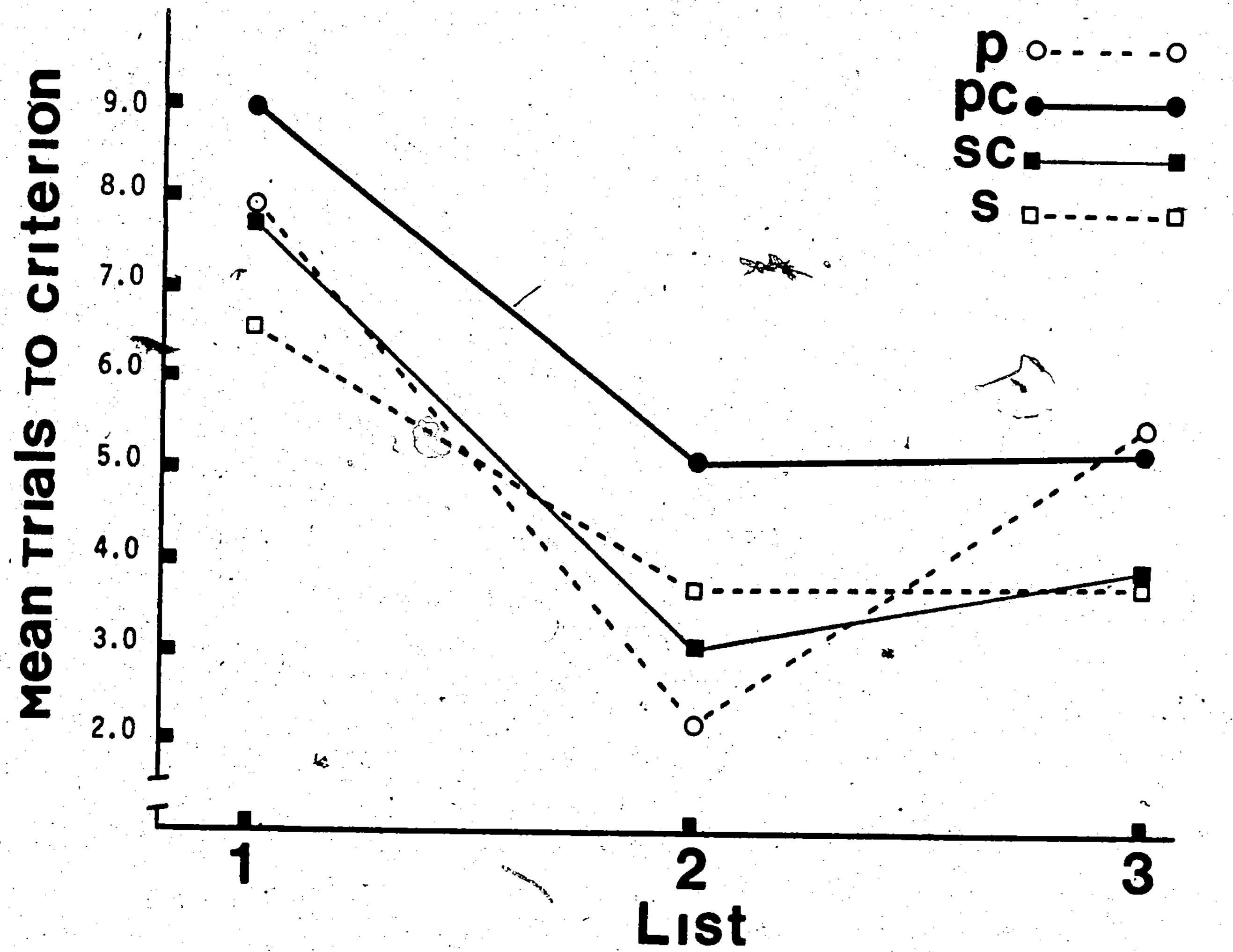

Figure 3: Mean trials to criterion per list for Experiment I.

The lack of reliable negative transfer in the PC group was unexpected since the second and third lists for the P and PC conditions were identical. It may be that the phonemic attribute is not usually used in learning common words, and must be primed before it becomes effective. This would seem to be supported since the semantically primed group also did not differ from the control on third list learning. If S condition Ss were able to avoid the interference due to phonemic similarity it was expected that they would perform better than the PC group and much like the SC group. If, on the other hand, the S group was unable to avoid the interference, it should have behaved more like the PC group which was a negative transfer paradigm on List 3. Since the S, SC and PC groups were statistically equivalent in performance on this list, strong support for either hypothesis was not indicated. The trend however, suggested that Ss in the S group were able to avoid interference on the third list. This trend then, although not reliable, seemed clear and thus, further examination of the results was indicated.

Intrusion errors on third list data were examined in order to provide a more adequate appraisal of the results. These are presented in Fig. 4. The nature of the task is such that all overt errors on List 3 necessarily must be intrusions from List 2, since the same response array was employed in all conditions. However, the intrusion data here consist of those overt errors which were previously paired with List 2 stimuli but were repaired on List 3 to similar stimuli. For example, if on List 2, "CRAZY" was paired with button #3 and on List 3, "LAZY", its phonemic counterpart was paired with button

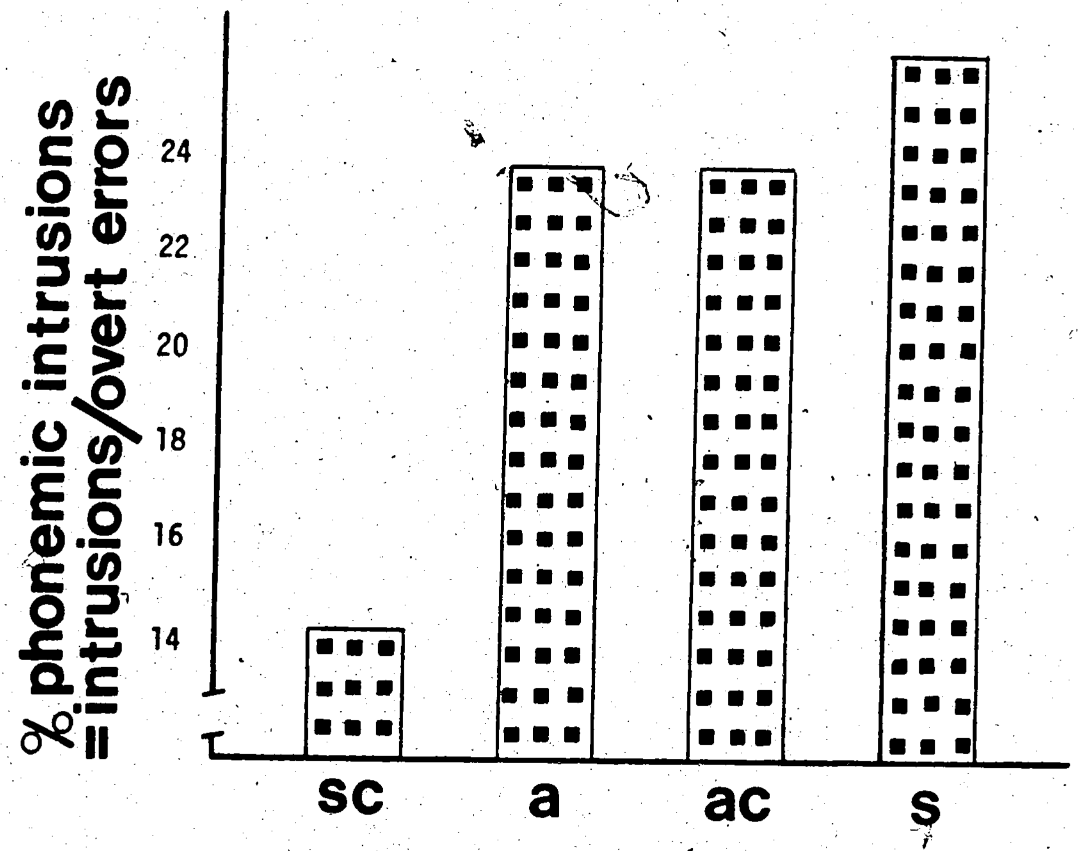

Figure 4: Percent phonemic intrusions on List 3 for Experiment I.

#1, an intrusion was recorded if S pushed button #3 when "LAZY" was presented during List 3 learning. It is apparent that in the interference conditions, S, PC and P, these intrusions are due to confusion of phonemically similar stimuli. In the SC condition, no phonemically similar items occurred in the third list. Therefore, any incorrect response made to a stimulus on List 3 which was correct on List 2 for the stimulus in that position, was recorded as an intrusion. This group thus served as an empirical control for errors in responding. Subjects learning this button pushing task do not make random errors and therefore the chance level of 20% was not an appropriate control for intrusion errors. Subjects tend to make specific kinds of errors. Incorrect responses tend to be position errors rather than random errors. A common error results from the confusion of the left side of the response panel with the right side, such that buttons #1 and #6 and #4 and #2 tend to be confused. Adjacent buttons are also commonly confused. This bias in incorrect responding, then, prevents the chance level due to random responding from being an appropriate control for phonemic intrusions. However, the SC group which had no phonemically similar items on the third list provided a perfect control for this kind of bias in overt errors.

Figure 4 serves to illustrate the abundance of phonemic confusions in all three inteference groups, with the S group making slightly more intrusion errors. The data were adjusted to provide the number of intrusions made compared to the number of opportunities for this kind of error, as only overt errors could be intrusions. As can be seen, the number of phonemic intrusions in the S, P and PC groups was high relative to the SC control. This occurred in spite of Ss tendency to confuse positions when making errors. These data seem to demonstrate the inability of the semantically primed Ss to avoid the interference due to phonemic similarity even though the other performance measures suggested a trend in the opposite direction. This seeming contradiction in the data prevented any clear conclusions to be made about the hypotheses.

In light of the intrusion data, the lack of statistically reliable differences between the S, SC and PC groups in third list performance precluded an adequate assessment of the hypotheses. Marked negative transfer with phonemic similarity using two lists has been previously obtained (Wickens, Ory and Graf, 1970). Since it was felt necessary to discover where the PC group lay in comparison with the other conditions, another experiment was conducted. Experiment II was designed to clarify the results obtained in the first experiment. The three original conditions, S, SC and PC were replicated using different stimulus materials in an identical task and similar design. In addition, a two-list negative phonemic condition was included in order to investigate further this paradigm.

Similarity in this experiment was varied in the same way as in the first experiment. The adjectives although different, appeared to be of approximately the same difficulty. With the exception of the previously outlined modification of the design, all other parameters were those used in Exp. I except the criterion of learning. Performance was required to three perfect trials not necessarily in a row, with Ss having at least five trials on all lists. This was done to permit greater experience with the lists, and thus hopefully, greater chance of the occurrence of transfer effects.

Experiment II

Method

Design and materials. The task in this experiment was identical to that used in Exp. I. Six two-syllable adjectives were learned with push-buttons serving as responses. Six different lists were required. The conditions were those from Exp. I with one exception as discussed above. The PHONEMIC group with phonemic similarity across all three lists was changed to a two-list condition. Phonemic similarity was present from List 1 to List 2 and List 2 responses were repaired. Thus, this group was like the PHONEMIC group of Exp. I with the omission of the first list. All groups except the SEMANTIC CONTROL learned identical second and third lists with only the first list defining the condition. The last two lists were constructed such that equal numbers of Ss within each condition learned each list second or third in order of presentation. That is, half the Ss learned the other half's second list third and third list second. The stimulus materials used in this experiment are presented in Appendix A.

Apparatus and procedure. The apparatus and procedure were identical to those used in Exp. I. Learning was taken to three perfect trials not necessarily in a row and at least five trials on all lists.

Subjects. A total of 96 Ss were required with 24 Ss participating in each of the four conditions. The majority of these Ss had not previously participated in a psychology experiment. Some _Ss_ were participating as an option for course credit and others were paid a standard sum for their participation. Subjects were assigned to conditions as they appeared in the laboratory according to the scheme outlined for Exp. I.

Results

As in Exp. I, the data were initially subjected to One-Way Analyses of Variance of each list, with four treatment groups in List 1 and 2 and three groups in List 3. Since the four performance measures used in the first experiment generally reflected equivalent results, only mean errors and mean trials to criterion were examined in the present experiment. Mean errors were again considered as the primary performance indicator. The results of these measures are presented in Table 2 and the Analyses of Variance in Appendix C. One-tailed t-tests were used for individual comparisons since Exp. I served to provide information about the expected direction of the differences. It also should be noted that the nature of the two hypotheses is such that any differences in performance can be predicted in only one direction, with respect to the appropriate control groups.

Analyses of List 1 performance. No differences in first list performance were obtained with all F's $(3,92) < 1$.

Analyses of List 2 performance. The overall $F(3,92) = 2.25$, $p < .10$, for mean number of errors on this list. Individual comparisons of the PC and P conditions showed very close to significant

Table 2

Results for Experiment II

	Cond	List 1	List 2	List 3
Mean Errors to Criterion	SC	25.13	8.96	6.88
	S	23.38	6.96	11.67
	PC	26.96	9.29	12.13
	P	24.25	13.42	
Mean Trials to Criterion	SC	11.04	6.92	6.17
	S	10.88	5.96	7.83
	PC	12.04	6.92	7.42
	P	11.21	8.33	

interference in the P group ($t = 1.62$, $p < .10$). Since the PC control group learned a C-B second list which is considered to be slightly negative, interference in the P group may have been adequately demonstrated. The S and SC groups were not statistically different from the PC control. Figures 5 and 6, depicting mean errors and mean trials to criterion for each list, show however, that a facilitory trend was present in the S group.

Analyses of List 3 performance. The overall analysis of this list for mean number of errors was close to significant, $F(2,69) = 2.41$, $p < .10$. Individual comparisons with the SC control showed significant negative transfer in the S group ($t = 1.81$, $p < .05$) and in the PC group ($t = 1.98$, $p < .05$) for mean number of errors.

Thus, performance of the S and PC groups on List 3 was disrupted with the SC group performing significantly better on this list.

Discussion

Positive transfer on the second list in the S and SC groups was not as great as expected. However, a trend on this list in the direction of facilitation was obtained in the S group. Figure 7, illustrating mean correct responses per trial for the first five trials on this list, shows a small but consistent facilitory effect in the S condition for the first four trials as compared to the performance of the PC control group. The SC condition performed slightly better than the PC group on the first three trials of this list. Positive transfer in these two groups in Exp. I was also not marked. The positive effect with semantic similarity

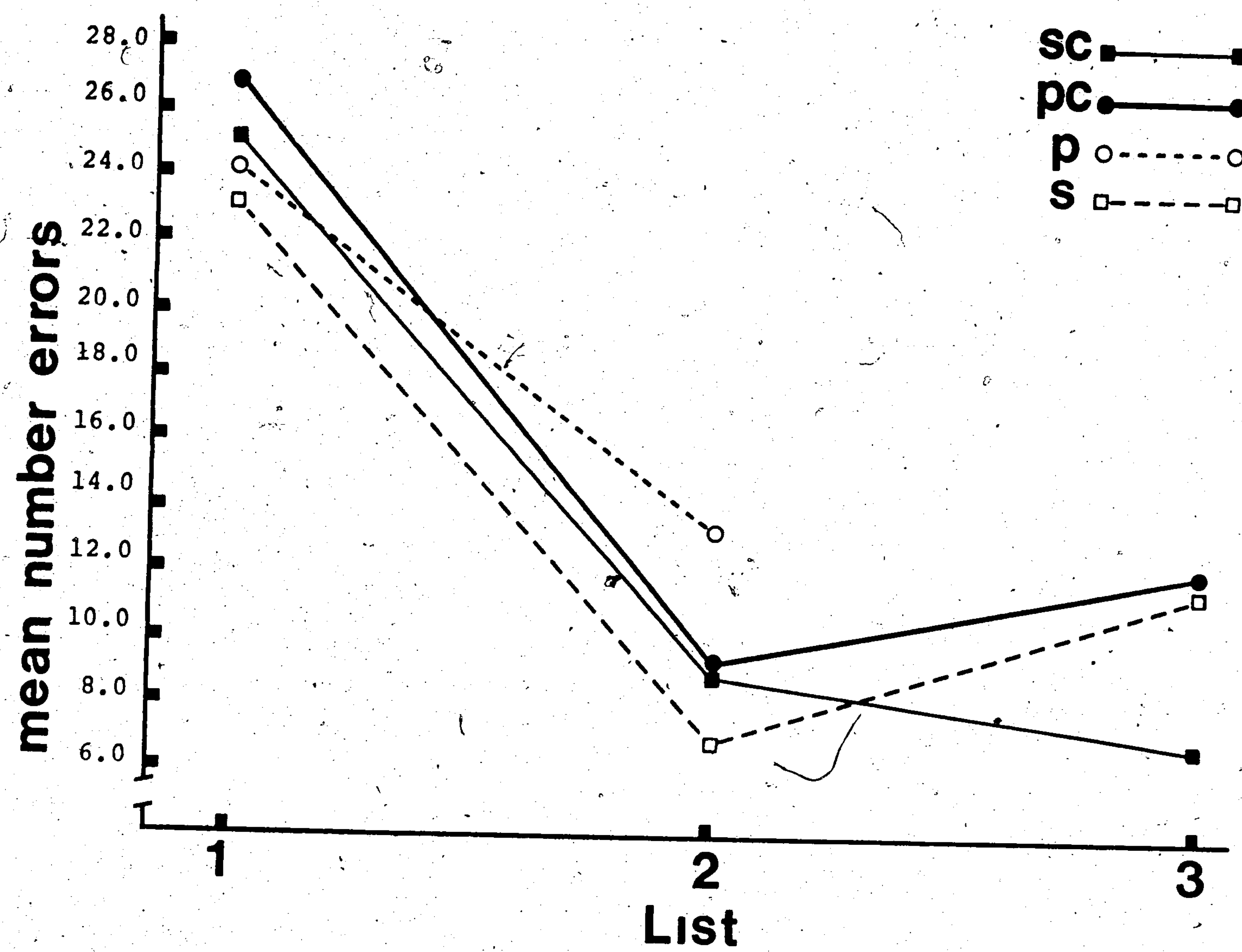

Figure 5: Mean number of errors per list for Experiment II.

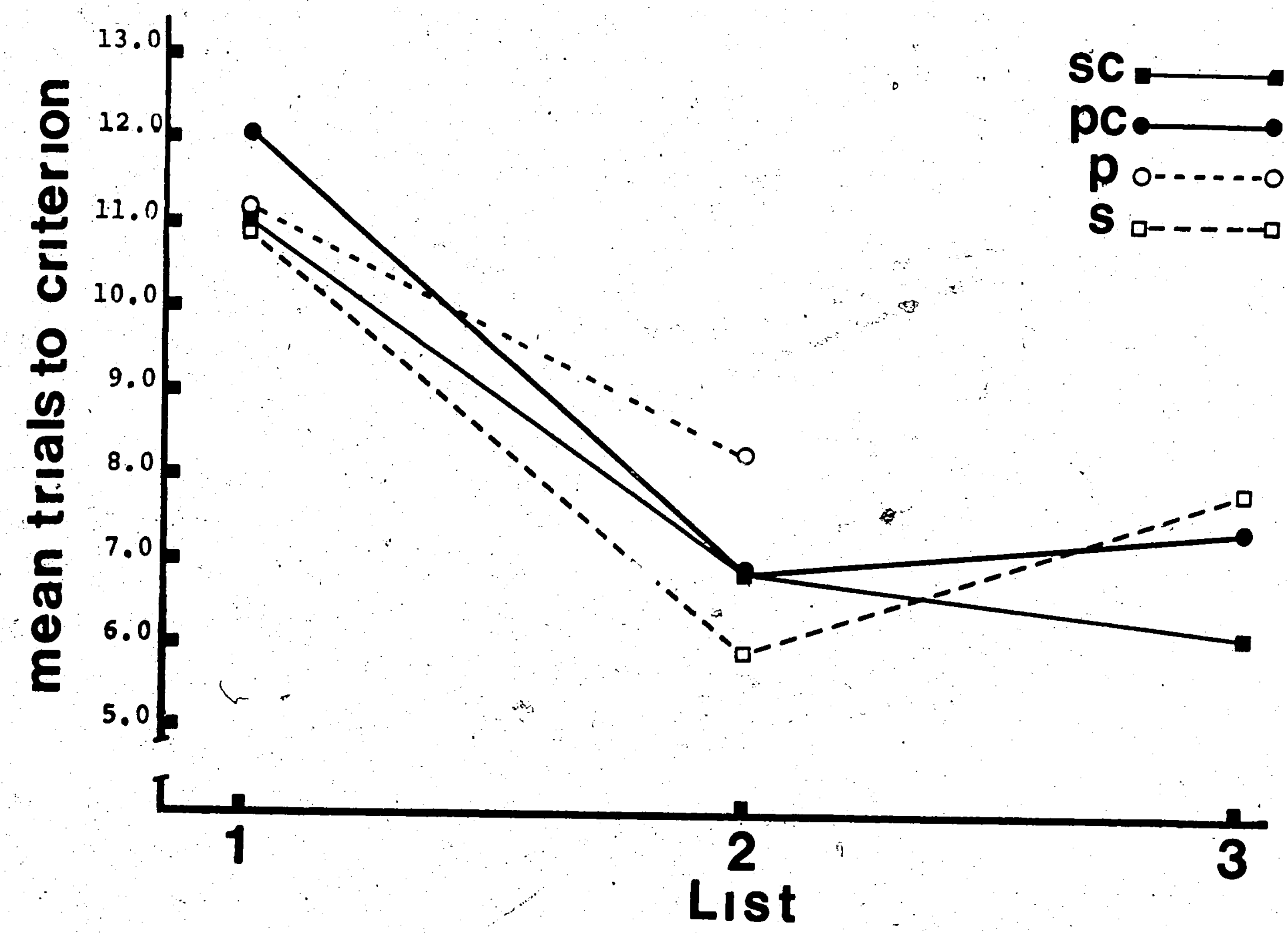

Figure 6: Mean trials to criterion per list for Experiment II.

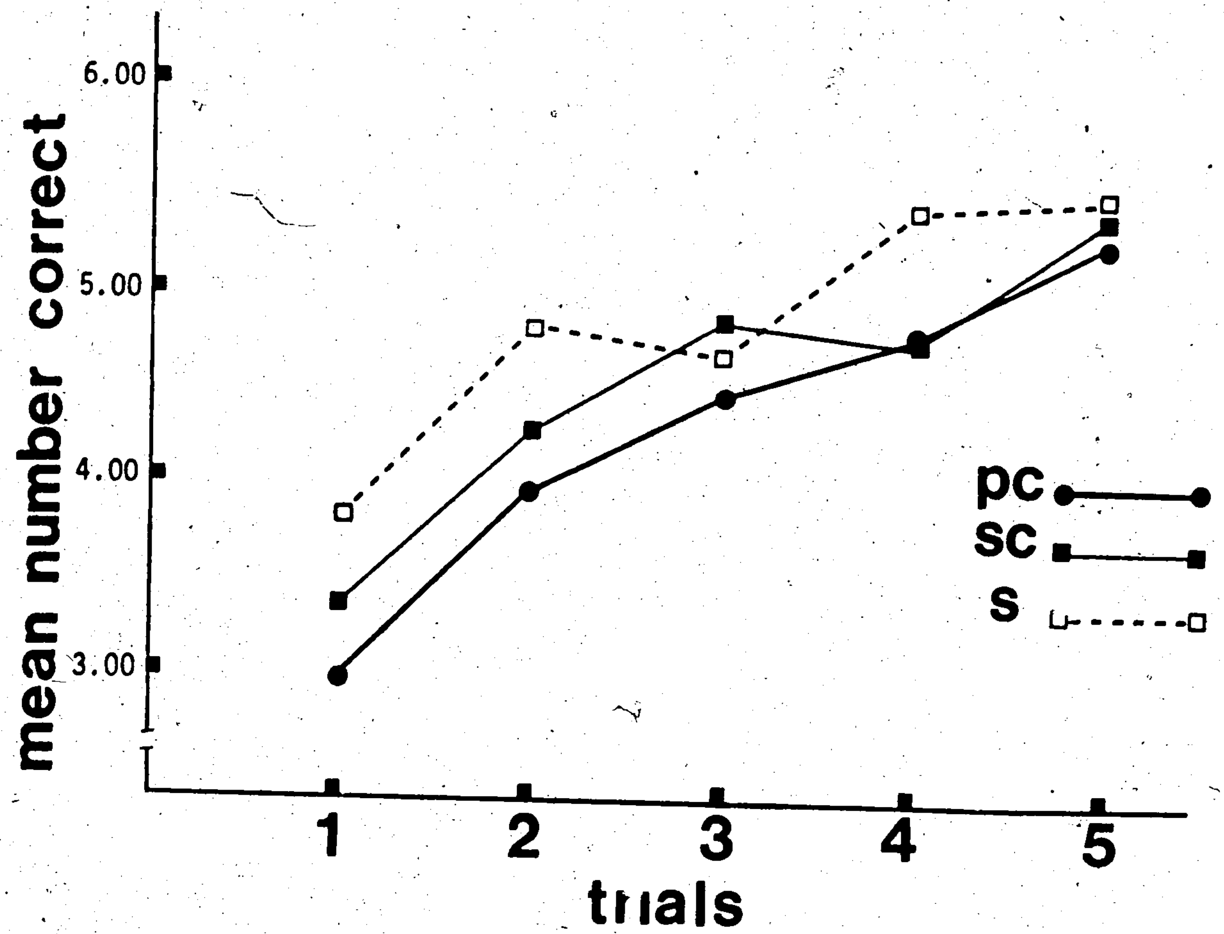

Figure 7: Mean number correct per trial in List 2 of Experiment II.

appears then, to be a consistent one although not as great as in the phonemic demension.

The two-list negative condition in Exp. II demonstrated adequate negative transfer since it was very close to significant when compared to a control group which is considered to be slightly negative in design.

On the third list, the S and PC groups performed significantly more poorly than the SC control. This result suggests that phonemic similarity can affect the efficiency of semantic encoding in certain situations. Since Ss were encouraged to code in meaning, the phonemic attribute must have influenced or interacted with semantic processing. Since processing of the phonemic attributes served to interfere with learning, Ss under these conditions appeared unable to avoid activating phonemic encoding even when another code provided adequate discrimination between stimuli in the list. It appears then, that sufficient time and opportunity for establishment of semantic encoding is not sufficient for elimination of interference under some conditions of phonemic similarity.

General Discussion

Experiment I served to demonstrate that phonemic similarity can be an effective factor in positive as well as negative paradigms. The phonemically primed P group showed marked facilitory effects in second list performance. This suggests that some cases at least, the phonemic attribute may be used to advantage in LTM. This result does not accord with the conclusions of Wickens, Ory and Graf (1970), that the phonemic dimension operates differently in transfer than does the semantic dimension. While these investigators failed to obtain any facilitory effect with phonemic similarity, the present study obtained marked positive transfer with this dimension. Negative transfer in the phonemic dimension w obtained in the P group of Exp. I, as was expected. The semantically primed groups also showed facilitation in second list performance, although to a somewhat lesser degree than did the phonemic group. Third list performance of the semantically primed groups did not differ, although the experimental group (S) learned a phonemically similar but repaired list. It was suggested that the phonemic attribute is not normally used in learning common words and must be primed before it becomes an effective cue. Phonemic intrusions, those intrusions from the second list due to confusion of phonemically similar items, were examined. This analysis showed that phonemic confusions were plentiful in all interference groups, in that the number of intrusions in third list performance exceeded that of the control group. This finding provided evidence against the hypothesis that the phonemic attribute must be primed before it can become functional in LTM. In other words, the presence of equal intrusions in the phonemically primed group and the other experimental groups suggested that the phonemic dimension of words functions in LTM, even when it is not primed experimentally. Although the error and trials analyses provided some evidence for Hypothesis 2 of the introduction, the intrusion results appeared to deny this explanation. The intrusion data showed that the semantically primed Ss did suffer interference due to phonemic similarity which the other performance measures failed to detect. For these reasons then, Exp. II was designed to investigate this phenomenon further.

Since the phonemically primed group of Exp. I (P) adequately demonstrated both positive and negative transfer effects, it was not replicated. Instead, a two-list phonemic interference group was substituted. This group adequately demonstrated interference effects in transfer list performance. Semantic facilitation was not marked with the S group showing somewhat greater facilitation than the SC group which was a condition identical in principle. It was concluded that positive transfer in the semantic dimension is a relatively small but consistent phenomenon. Performance on the final interference list indicated poorer learning in the PC and S conditions compared to the control group. The semantically primed S group and the PC group suffered an equal amount of interference on this list. This finding demonstrated that even with familiar words as stimuli and ample time phonemic similarity can disrupt semantic encoding in LTM.

The results of Exp. II provided confirmation that selective encoding of words in LTM may be a relatively difficult process. Phonemic attributes appear to be encoded along with the meaning. It does not appear that the opportunity for semantic encoding can always prevent activation of the phonemic code even when its activation is disruptive. Since past work in this area has shown that Ss prefer to retain their original encodings and/or strategies, it does not seem logical that semantically primed Ss switched to a phonemic code on the third list and thus, suffered interference. It is more likely that these Ss retained their original strategy but were unable to ignore the phonemic similarity. Another explanation for the results could be that Ss in the semantically primed group learned, during List 2, that attending to meaning was a facile way to master the task. This strategy then, broke down on List 3 since the items were no longer synonomous with those in the previous lists. This would disrupt performance while Ss searched for the strategy which previously had been successful. It follows then, that the loss of a strategy rather than phonemic similarity, would be responsible for the interference in third list performance. This solution however, fails to account for the performance of the SC control group, which learned an unrelated third list. This group, like the S condition, was primed to code on meaning on List 2. On List 3, this group showed no interference effects, performing significantly better than the S and PC groups. If the above proposition was correct, the SC group should have performed as poorly as the S group, since these Ss had also lost their previous strategy. Alternatively, it could be suggested that instead of learning to look for meaning compatibility as a strategy, the S and SC groups learned the strategy of looking for similarity relations. If the S and SC groups learned to search for any similarity relation between List 3 and List 2, the S group would presumably attend to the phonemic dimension since this dimension related the items from the second and third lists. The SC condition Ss, on the other hand, would find no relationship between these items. This explanation for the interference in performance seen in the S group would seem to be a tenable one. The investigator has no way of determining the probability of this proposal as an adequate explanation of the results of the present experiment. On questioning the Ss following their participation in the experiment however, it was found that very few were aware of any similarities between the lists, and thus, if a searching strategy was employed by Ss, they were not aware of doing so.

The results of third list performance in Exp. II provide some evidence for the influence of phonemic similarity on semantic encoding in LTM. With common words as stimuli and ample time for processing, semantic encoding would provide effective and reliable discrimination between semantically dissimilar items. Phonemic similarity should logically not interfere with learning in this case if selective encoding of the semantic attributes of the items occurs. It appears then, that in the transfer paradigm, Ss are not able to selectively code on the semantic attributes of words when phonemic similarity is present. Further evidence for the effects of phonemic similarity on semantic encoding is provided by Singer and Cole (1973). They found that semantic satiation increased the latency of Ss ability to pronounce phonemically similar words to those satiated. An unpublished study (Runquist and Evans) found evidence that reaction time for processing the meaning of semantically similar word-pairs increased if the pair was also phonemically similar. Thus, in some cases at least, phonemic similarity can disrupt semantic processing. The present study served to show that phonemic similarity can interfere even when items are semantically dissimilar as shown by the results of third list performance. It seems then, that encoding in LTM of highly meaningful materials is a complex process and selective processing of attributes may not be possible in some situations.

Very little research has been directly concerned with this problem. The majority of the published work has been primarily concerned with the effects of similarity on the response side in the transfer paradigm. Wickens, Ory and Graf (1970) obtained negative transfer with phonemic similarity but failed to obtain any positive effects with the facilitative A-B, A-B' model. They concluded that while semantic transfer occurs in both the positive and negative dimensions, the phonemic attribute operates differently in LTM. Investigations involving stimulus similarity have produced inconsistent results. McGlaughlin and Dale (1971) found significant positive transfer with phonemic similarity of stimuli in A-B, A'-B, while Bruce and Murdock (1968) and Dallett (1966) obtained no phonemic similarity effects in a positive or negative paradigm. The inconsistency of the results make definitive conclusions difficult. Experiment I of the present research demonstrated positive transfer and negative transfer with phonemic similarity. Although the present study differed from those mentioned in that three lists were employed, the facilitation due to phonemic similarity obtained in the first experiment, occurred on the second list and thus, followed the simple A-B, A'-B model. It is clear, that in some cases positive transfer does occur with phonemic similarity and thus, the phonemic attribute may be utilized in LTM in some situations.

The present research has provided evidence that word codes may consist of a complex of attributes. The meaning, phonemic properties and perhaps graphic cues etc. may make up these kinds of codes. At least one of these properties of words, the phonemic one, may be automatically processed along with meaning. Subjects do not appear able to code selectively on just meaning of words even though this cue may provide perfect discrimination. Subjects seem able to use phonemic properties of words as an additional aid in learning when these properties provide further discrimination. In other words, it may be that an attribute may be made dominant in some way, but not to the extent that the less dominant attributes can be ignored. Thus, when meaning is relevant, this cue may be used to a greater extent for retrieval than other cues. When sound is relevant, this cue may dominate others in retrieval. In this way then, when Ss have been encouraged to attend only to meaning, the phonemic attribute, if redundant, will persist in disrupting performance since, although it may be less important as a cue, it cannot be completely ignored. Whether other word attributes function in the same way in LTM is a problem worthy of investigation.

<u>Conclusions</u>. The results of the present research allow several conclusions. The phonemic attribute is clearly functional in some LTM situations. Phonemic similarity can serve to facilitate performance in a positive transfer paradigm and disrupt performance in a negative paradigm. This negative effect occurred with and without previous phonemic priming in the present investigation. Facilitation due to semantic similarity is not as marked as with phonemic similarity.

Interference due to phonemic similarity seems to persist even when <u>S</u>s have been previously primed or encouraged to attend to meaning.

The function of the phonemic attribute in long-term retention of words is a complex one. It does however, appear to be a potent factor even with highly meaningful materials. Phonemic similarity may well be as effective a cue in LTM as it has shown to be in STM.

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APPENDICES

APPENDIX A

Stimulus Materials

Table 1

Lists for Experiment I

List 1	List 2	List 3
S	**S**	**All Groups**
DESTINED	FATED	DATED
CRAFTY	CUNNING	STUNNING
ROCKY	STONY	PHONY
PREPARED	READY	HEADY
INSANE	CRAZY	LAZY
ABSENT	MISSING	HISSING
SC	**SC**	
TOTAL	ENTIRE	
USELESS	FUTILE	
HARDY	STURDY	
ALIEN	FOREIGN	
DOUBLE	TWOFOLD	
COMIC	FUNNY	
P	**P**	
RATED	FATED	
RUNNING	CUNNING	
BONY	STONY	
STEADY	READY	
HAZY	CRAZY	
KISSING	MISSING	
PC	**PC**	
URBANE	FATED	
FESTIVE	CUNNING	
CLASSIC	STONY	
FLESHY	READY	
LAWLESS	CRAZY	
FIENDISH	MISSING	

Table 2

List for Experiment II

	Order of Presentation
SEMANTIC CONTROL	Order 1 - 3 6 2
	Order 2 - 3 6 1
SEMANTIC	Order 1 - 4 1 4
	Order 2 - 5 2 1
PHONEMIC CONTROL	Order 1 - 3 1 2
	Order 2 - 3 2 1
PHONEMIC	Order 1 - 1 2
	Order 2 - 2 1

3	4	5
EXACT	GHOSTLY	TIRED
TOTAL	INSANE	IDLE
EMPTY	PREPARED	CONSTANT
USELESS	DISMAL	SPACIOUS
ALIEN	ROYAL	AWFUL
PERFECT	CRAFTY	STYLISH

6	1	2
PRECISE	EERIE	WEARY
ENTIRE	CRAZY	LAZY
VACANT	READY	STEADY
FUTILE	GLOOMY	ROOMY
FOREIGN	REGAL	LEGAL
FAULTLESS	CUNNING	STUNNING

APPENDIX B

Instructions for Ss

Experiment I and Experiment II

The particular experiment in which you are about to participate is part of a project concerned with association learning. One of the ways in which associations can be studied is to have Ss learn word-word, word-figure or word-number pairings. By studying the rate at which various kinds of materials can be learned under various conditions we hope to find out just how association learning takes place and what the factors are which influence it.

In this experiment it is very important that you follow the instructions to the best of your ability. Should you fail to follow or understand any instructions, be sure to let me know since the interpretation of the results may be affected. In front of you is a board with six lights and six buttons mounted on it. You are going to learn (3 or 2) lists of six two-syllable adjectives. The adjectives will be presented one at a time on the screen in front of you. Along with the appearance of each adjective one of the six lights on the board will light up. Thus, during this period you will see six adjectives one at a time, each paired with one light. Following this, the screen will go blank and the test period will begin. At this time each adjective stimulus again will appear one at a time on the screen. Now, however, the lights will not occur. Your job is to remember and push the button under the light which was previously paired with each stimulus before the next adjective stimulus appears on the screen. Remember you must push the button before the next adjective stimulus appears on the screen. Thus, during the study period you will simply study the adjective-light pairs and during test you push the correct button as each stimulus appears. This study-test procedure will be repeated over and over again. It is very important that you try to do the very best you can and to attempt to respond by pushing a button each time during the test period. Do not worry about making mistakes.

The pairs will be presented quite quickly so it is important that you pay full attention to the task.

Questions?

Second and third list

Now you are going to learn another list of six two-syllable adjectives again paired with lights. The procedure is exactly the same as for the previous list.

Questions?

APPENDIX C

Analyses of Variance

Table 1

Experiment I

ANOVA Errors to Criterion

Source	df	Mean Square	F
Between Groups	3	222.83	0.73
Error	76	303.53	
List 1			
Between Groups	3	218.65	4.18**
Error	76	52.32	
List 2			
Between Groups	3	94.72	2.89*
Error	76	32.78	
List 3			

* $p < .05$

** $p < .01$

Table 2

Experiment II

ANOVA Errors Trials 1 & 2

Source	df	Mean Square	F
Between Groups	3	15.95	2.62
Error	76	6.09	
List 1			
Between Groups	3	30.55	4.30**
Error	76	7.11	
List 2			
Between Groups	3	9.65	1.24
Error	76	7.80	
List 3			

** $p < .01$

Table 3

Experiment I

ANOVA Trials to Criterion

Source	df	Mean Square	F
Between Groups	3	21.05	0.55
Error	76	38.04	
List 1			
Between Groups	3	29.95	2.94*
Error	76	10.19	
List 2			
Between Groups	3	16.50	2.97*
Error	76	5.55	
List 3			

* $p < .05$

Table 4

Experiment I

ANOVA Errors to First Correct

Source	df	Mean Square	F
Between Groups	3	64.88	1.89
Error	76	34.37	
	List 1		
Between Groups	3	47.21	3.74*
Error	76	12.63	
	List 2		
Between Groups	3	42.75	2.17
Error	76	19.68	
	List 3		

* $p < .05$

Table 5

Experiment II

ANOVA Errors to Criterion

Source	df	Mean Square	F
Between Groups	3	56.26	0.17
Error	92	323.71	
List 1			
Between Groups	3	176.32	2.25
Error	92	78.20	
List 2			
Between Groups	2	202.93	2.41
Error	69	84.04	
List 3			

Table 6

Experiment II

ANOVA Trials to Criterion

Source	df	Mean Square	F
Between Groups	3	6.44	0.27
Error	92	23.83	
	List 1		
Between Groups	3	22.98	2.05
Error	92	11.20	
	List 2		
Between Groups	2	18.06	2.10
Error	69	8.59	
	List 3		