TRANSFER AND GENERALIZATION OF THE
INHIBITORY POTENTIAL DEVELOPED
IN ROTE SERIAL LEARNING

by

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CHAPTER I

INTRODUCTION

Presented in this chapter are: (1) a statement of the problem that was investigated in this study, (2) the historical information that was relevant to the problem, and (3) the significance of an investigation of this nature.

In this section pertaining to the statement of the problem, the specific hypotheses that were tested in this investigation are outlined along with a brief description of the methodology employed.

The historical section presents a general review of the apposite literature drawn from various areas of the psychology of learning: (1) serial learning, (2) reminiscence, and (3) transfer effects. The decision to review these three extensive areas was based upon the uniqueness of the problem in that it stems from no single series of research.

In the final section of this chapter, the significance of a study such as this is viewed in the light of the conclusions drawn from the historical review.

STATEMENT OF PROBLEM

In the psychology of learning there has been considerable experimental investigation and theoretical analysis relating to transfer of training. As a result of such studies there is a sighificant body of knowledge on the positive or facilitative effects and on negative or inhibitory effects of the transfer from a prior learning experience to a subsequent learning task. There is however relatively little adequate information available on those factors which interfere with the learning process. In the course of any given learning experience conditions may exist within the learning situation itself which facilitate or inhibit the acquisition of various parts of the associations or activities to be learned. The nature of the mechanism of transfer of training in this type of situation and especially the negative or inhibitory aspects of the transfer have not yet been sufficiently investigated.

The purpose of this study was an attempt to determine whether the inhibitory potential assumed to develop in rote serial learning would transfer to identical and similar items in paired-associates learning. This inhibitory potential has been postulated in part to account for the serial position phenomenon, as graphically described by the bow-shaped curve of rote serial learning, and it has been useful in offering an explanation for the differential ease of learning the items in a serial list. Hull and his associates (17) refer to the inhibitory effects as being the result of the presence of an inhibitory potential (Ir) which they relate to an assumed principle of "inhibition of delay". It is, therefore, of theoretical interest to determine whether the inhibitory effects would carry over to situations other than those in which they were developed.

Following the lead of Hull, the present study assumes but also tests for the development of inhibitory potentials during the process of learning by rote a serial list of verbal items. The specific hypotheses under test are as follows:

HYPOTHESIS I: The inhibitory effects on those items occupying the middle positions of a serial list can be demonstrated with subjects in the age range of 9 to 13 years.

The verification of this first hypothesis is necessary in establishing the conditions required to test the remaining hypotheses which represent the major purpose of this study.

HYPOTHESIS II: Syllables that are learned in the middle positions of a serial learning list will be more difficult to learn in a paired-associate learning situation, when paired as stimuli with new response syllables, than those syllables that are located at or near the ends of the serial list originally learned.

This hypothesis defines the prediction of the transfer of an inhibitory potential to a learning situation in which the development of any new inhibitory effects is experimentally controlled. The presence of any inhibitory effects can, therefore, be considered as having been induced in the previous learning situation.

HYPOTHESIS III: The syllables in the middle of the list will be relatively more difficult to learn than those at the ends when the paired associate learning follows immediately after the serial learning than when a longer delay period intervenes.

This prediction is based upon the supposed rapid dissipation considered as a characteristic of the inhibitory potential.

HYPOTHESIS IV: Syllables which are either phonetically similar or physically similar will also demonstrate comparable difficulties in the learning of a second set of verbal materials.

This hypothesis represents a secondary aspect of the study and investigates the extent of generalization of the transferred inhibitory potential to similar items.

In order to test these hypotheses with satisfactory experimental rigor the basic design that was used in this study followed a modified paradigm of experiments on transfer of training, viz: initial learning situation followed by the test learning situation. The initial learning situation for this study was a serial rote learning task presented under conditions that maximized the probability for the developing of the inhibitory potential and provided an operationally definable demonstration of the effects. Paired associates learning by the method of adjustment served as the test learning situation since it controlled the development of inhibitory potentials, but permitted the demonstration of previously induced inhibitory effects.

Three major independent variables were investigated in this study: (1) position of item in a serial learning list, (2) the time interval between the prior and the test learning situation, and (3) the similarity of the paired-associate stimulus member to its counterpart syllable in the serial list.

REVIEW OF PERTINENT LITERATURE

Serial Learning. In this section we will review the: (1) experimental evidence of serial position effects, (2) theoretical interpretation of this phenomenon, and (3) recent formulations used to predict the form of the bow-shaped curve of serial rote learning.

In the learning of verbal materials, comprised of discriminable and approximately equal parts, it has been repeatedly demonstrated that the speed of learning the various items in the list is partially a function of the serial position of the items.[1] Perhaps the most popular example of

[1]Extensive reviews of serial learning have been made by McGeoch (20) and by Hovland (13).

this relationship is the serial task involving the rote memorization of a list of nonsense syllables. That the items near the middle positions are learned more slowly than the items in the beginning and end positions was reported as early as 1902 by Ebbinghaus (32, p.22). He used what would now be considered as the anticipation method to learn 48 lists of ten words each. His interpretation was that the observed serial position effects were the result of greater attending on his part to the syllables at the beginning and end of the lists than to those in the middle.

During the following half-century, serial position effects on learning were studied and found to be present under a large number of conditions. Characteristic curves of the relative ease with which end items are acquired in comparison with the middle items have been reported and described by the "bow-shaped curve of serial position." Curves of this nature are most readily obtained with verbal materials by using the anticipation method of serial learning. This technique provides a record of the subject's response to each item and for every trial. Curves typical of the relations obtained with verbal lists of nonsense syllables are those of Lepley (18), Ward (31), and Hovland (11). Similar results were also obtained by Robinson and Brown (26) for three-place numbers, by Melton and Stone (21) for dissyllabic adjectives, and for trisyllabic adjectives by Noble (22).

Although serial position effects have been most regularly obtained with verbal materials, particularly with nonsense materials, similar effects have been obtained with other learning tasks. Serial position effects in the learning of mazes by human subjects have been obtained by Warden

(13, p. 628) and Lumley (19). Similar results with rats have been reported by Hull (16).

As in other studies of verbal learning, the greater portion of serial position studies have used college students as subjects. Very little information is available as to the presence of this aspect of learning behavior in young children. Lepley (18) used young adolescents in the age range of 14 to 17 years. He found the position effects present in both 8th and 11th grade groups but more predominant in the older group.

The array of experimental evidence available demonstrating the characteristics of the bowed serial position curve has encouraged the application of the term "universal" in referring to this phenomena (3, 13, 20). In regard to this statement of universality it is pertinent to recall McGeoch's (20 p. 107) appropriate warning,

> ..... even with homogeneous materials practiced under carefully controlled conditions, the detailed characteristics of the bow-shaped serial position curve vary with conditions, of which distribution, rate of presentation, and prior practice are examples. The introduction of variations in direction of effort or of uncontrolled order of recall will alter the curve still further.

Some of the conditions of which the demonstration of serial position effects is a function was explored by Hovland (9, 10, 11, 13) in his studies which dealt with the phenomena of reminiscence. He obtained steeper gradients of the position effect under both conditions of massed practice and a rapid rate of syllable presentation. The greatest position effects occurred at a presentation time of two seconds per syllable and a rest interval of six seconds between trials. Hovland also found that under the above conditions, position effects become still more pronounced as the length of the list of nonsense syllables increases from eight to fourteen items.

Although experimental substantiation of this intraserial phenomena is readily available, acceptable theoretical explanations to account for it have been highly controversial. Ebbinghaus (32, p. 22) had attributed his results to differential attention during the learning process. A "law of primacy" and a "law of recency" (20) have been suggested to account for the differential learning of the first and last items in a series as against the middle items. McGeoch (20, p. 115) is inclined to disregard the value of these concepts as explanations, stating, "Primacy and recency have significance only because of the conditions correlated with them."

Two major theoretical explanations have been developed during the past 30 years to account for the observed serial position curves. Both theories discuss the phenomena in terms of the presence of inhibitory effects operating within the learning situation.

The older of the two theories stemmed from traditional functionalism in psychological learning theory and was first proposed by Woodworth and Poffenberger in 1920 (20, p. 110). A more systematic and formal formulation of the theory was presented in 1928 by Foucault, (6; 20, p.111) who utilizes the concepts of proactive and retroactive inhibition and related intraserial phenomena to those characteristics that are usually observed in interserial phenomena. The specific hypothesis that Faucault formulated was to the effect that the relations between rate of learning and ordinal position in the list are a function of proactive and retroactive inhibition. Each item within the list, other than the first, was considered as exerting a retroactive inhibitory effect on all preceding items and all items, excluding the last one in the list, were considered to have a proactive inhibitory effect upon those that follow. The initial item is free of proactive inhibitory effects, and the final item is free of retroactive inhibitory effects. Those items that occupy positions either in the beginning or end of the list are relatively freer from their respective inhibitory effects than those items that are in the reverse position. The items that occupy the middle positions are subject to the full influence of both forms of inhibitory effects.

Foucault's evidence in support of his hypothesis was drawn from data from a large group of children for immediate recall of lists ranging from 3 to 7 words per list. His results indicated that as the number of items in the list increased, greater forgetting of the initial item occurred when tested for immediate recall. From this he inferred an increase in retroactive inhibitory effects as the number of items in the list increased. His test for the effect of proactive inhibition on the recall of the last item in the list, however, did not show the same trend with increase of items in the series. According to Foucault's formulation, the 4th item in a 7 word series, when tested on immediate recall, should demonstrate the additive effects in both forms of inhibition arising from the three words that may produce the proactive effects and the three which may serve in creating retroactive effects. His results indicated greater inhibitory effects operating on the fourth item than had been anticipated, i. e., the combined proactive and retroactive inhibitory effects were greater than the sum of the influences of the three antecedent and three subsequent words. Foucault accounted for this by assuming that the connections of succeeding words are weakened by proactive inhibition and are thus less able to resist retroactive inhibition from subsequent words.

Working within the same frame of reference, McGourty (20, p. 112) investigated whether or not variations in similarity between the component items of a series showed the same effects as would be predicted from similarities between two lists on proactive and retroactive inhibition. He found that the similarity factor, when introduced within and between the first and last group of three items of the list, operated to decrease the degree of learning of the early and late positions (similar items) and to increase the learning of the intermediate items. He concluded that his findings strongly supported the interpretation that serial position effects are the result of intralist proactive and retroactive inhibition.

The second and more recent theoretical explanation of the serial position effects was developed by the Yale group under the leadership of Hull. In his recent review of human learning, Hovland (13, p. 624) remarked, "Serial position effects play a prominent part in the rote-learning theory advanced by Hull et al." The converse may also be stated, i. e., perhaps the most prominent and critically evaluated interpretation of serial position effects is the one proposed by Hull (14, 17). This explanation developed from his deductive technique by which theorems concerning rote learning could be derived from a set of postulates and definitions. Hull's theory of the phenomena of serial position is also in terms of inhibition but differs from the one previously discussed in that the inhibition is the result of position-spanning remote associations. In this formulation, principles derived from conditioning experiments play an integral part.

The first formal attempt to apply principles of conditioning to the phenomena of rote learning was made by Lepley (18). He proposed that any item in a serial list, excluding the last one, serves as a conditioned stimulus for evoking conditioned responses which are the items appearing later in the list. The response of any item or syllable to an immediately preceding item, serving as a conditioned stimulus, may be considered as a simultaneous conditioned response. Remote forward associations between any two non-adjacent syllables are trace conditioned responses. The suppression of the anticipatory tendencies of the trace responses was considered as being an inhibitory process similar in nature to internal inhibition in conditioning.

Hull, in 1935 (14), expanded the Lepley hypothesis as a possible means to account for serial position effects. He posited that the remote associations, being similar to trace conditioned responses, are held in check from appearing too soon as anticipatory errors by an assumed principle of "inhibition of delay". According to his exposition, any item in a serial list will be inhibited in proportion to the number of remote associations spanning that item. From this analysis Hull could explain why the middle of the list was more difficult to learn than the ends but could not predict the result that the most difficult item is actually somewhat beyond the middle of the list. However, he was successful in deducing several other phenomena that were later confirmed by the research carried out by Ward (31) and Hovland (9, 10, 11.).

The most extensive statement by Hull and his associates of their theoretical interpretation of position effects appeared in the 1940 publication of their hypothetical-deductive system (17), which specifically dealt with the phenomena associated with serial rote learning. In this monograph Hull and his associates presented eighteen postulates from which theorems were developed and compared with available experimental evidence which served as tests of the theorems and postulates. Six of the postulates (Nos. 4, 5, 6, 7, 9 and 13) were concerned with the characteristics of the assumed "inhibitory potential".

This potential was defined (17, p. 24) as:

> A cumulative and relatively permanent organization (within a subject's body) which comes into action in differential amounts at the several syllable presentations of a syllable-presentation cycle, and which, at any syllable presentation, acts to diminish the functional potentiality of the concurrent excitatory potential.
> The concept 'inhibitory portential', like that of excitatory potential, is a logical construct and also clearly represents an unobservable entity.

In developing Postulate 4 (17 pp. 51-52) Hull attempted empirically to justify the assumed inhibitory potential. His major support was drawn from Pavlov's reported "inhibition of delay" and "inhibition of reinforcement". In recognition of the weakness of his empirical justification he stated,

> . . . . it is recognized that sooner or later these postulates themselves may be deducible from other still more basic postulates. . . . .
> . . . .
> . . . . it may be well to recall that the type of inhibition. . . manifests itself as at least a temporary neutralization of excitatory potentials. . . . Pavlov interpreted these phenomena in terms of a neurological theory of inhibition which, however, has not been generally accepted and is not accepted by the present writers.

Hull then referred to a "somewhat more plausible hypothesis" which had been advanced independently by Gibson and by Hovland. In essence, the alternate hypothesis explained the inhibition as being the result of competition between excitatory potentials which tend to neutralize each other and reduce the evocation potential of the more dominant tendency.

In the discussion of Postulate 5 (17 pp. 54-55) in which the existance of this hypothetical entity is assumed, a brief explanation is provided for the inhibition that occurs with the association of a particular syllable reaction to the "compound trace concurrent" with the stimulus syllable.

> . . . . a conflict will occur between the simultaneous tendency to speak "MAR" (the permissible anticipatory trace conditioned reaction) on the one hand, and "YOD" (evoked as the result of ordinary reading habits), on the other. These two reaction tendencies are obviously incompatible, since a person cannot speak both syllables at the same time. This conflict between incompatible excitatories potentialities should tend to a mutual neutralization of excitatory potentials and thus produce what we have called inhibition.

In developing this system of serial rote learning, Hull drew an anology between trace conditioned responses and remote associations in serial learning. Hilgard and Marquis (8, p. 225), as well as others, indicated several pertinent difficulties that were involved in Hull's analogy. Their major objection was in regard to the relative slowness with which trace conditioned responses are normally established while serial position effects can be observed very early in the serial learning process. The authors conclude, "It is more likely that the inhibition observed in serial verbal learning represents an interference between the correct tendency and the tendency to respond with the remote associations . . . . ."

Bugelski recently commented on this criticism voiced by McGeoch (20) as well as by Hilgard and Marquis against the assumption that remote associations are similar to trace conditionings. "The argument that trace associations are difficult to form appears to have developed from a too hasty acceptance of an analogy first used by Hull to illustrate the trace concept (3, p. 347)." Bugelski agrees that the type of serial learning involved can hardly be viewed as trace conditioning in the traditional sense. The suggestion is made that the serial learning should be related to "simultaneous conditioning to the trace of a stimulus" which need not precede its future associate by more than 24 seconds of time in an eight syllable list.

As mentioned earlier, a major problem for both the proactive, retroactive inhibitory theory and the Yale Group theory is the prediction of the point of maximum difficulty. Whereas, theoretical predictions would place the peak (point of greatest difficulty) in the middle of the list, factual data gathered in many experiments have shown that the items just past the middle are the last to be learned.

In order to improve the prediction of serial position effects, Hull in his 1940 publication fixed parametric values for the theoretical curves from the postulates. The prediction (17, p. 106) located the point of maximum difficulty just beyond the middle of the list and graphically provides a good fit for the emperical findings.

Bugelski (3), who had previously worked with Hull, extended the remote association explanation of the relative difficulty of learning nonsense syllables in a serial list. He believed that by developing more fully Hull's Postulates I and II (stimulus trace and afferent neural interaction), Hull's rote-learning system could approximate experimental data still more closely. Bugelski, therefore, posits that the remote associations that are alleged to be responsible for the inhibition of correct responses vary not only in number, as has been stated by Hull, but also in strength. In order to develop a theoretical expectancy curve for serial position effects, Bugelski deduced a system of weights to account for the different strengths of associations at different positions in the list. The strength value was determined both by the degrees of remoteness of the association and the amount of competition of associations possible with other responses. The latter point was based on the assumption that associations made in competition with a large number of others are less likely to be as strong as those which are made under conditions of little possible competition. According to this justification, he assigned a higher strength value to associations of the same degree of remoteness if they occur later in the series since there is less competition possible towards the end. Bugelski's weighted frequencies provided a theoretical curve which showed the greatest negative effect in learning to occur just beyond the middle of a list. His obtained empirical frequencies corresponded more closely to his theoretical curve than to Hull's (14) deduced curve.

Following the appearance of his monumental publication in 1940, Hull's interest appears to have veered from the relatively limited area of serial rote learning to that of total behavior. In 1943 he published an outline of a comparable system of total adaptive behavior. The entire area of serial rote learning in humans was virtually ignored and offers no opportunity for extending his interpretation of the bow-shaped curve of serial position. The construct of an inhibitory potential is involved in his second system and described in three postulates (15, p. 300). However, his point of departure is the Mowrer-Miller Hypothesis (15, p. 298) which "regards reactive inhibition as essentially a need to cease action, i. e., a need for rest; . . . . ." The inhibitory potential is differentiated into a reactive inhibition which has the characteristics of a drive-state and is dissipated quickly, and conditioned inhibition which is not dissipated in time. Insofar as the construct of the inhibitory potential as used in his system of serial rote learning referred, in the main, to the competition of responses, there appears to be no similarity in the origin of the inhibitory potentials posited in the two systems. The only similarity evident is with the reactive inhibition in that both are characterized as being dissipated rapidly in time.

A survey of the literature of the past decade has revealed only one discussion, by Hull, of serial position effects. This mention was an outgrowth of the study in animal learning reported above (16). Drawing an analogy between maze learning in the rat and human rote learning, he formulated an explanation which involved the concept of 'physiological summation' of the separate gradients of reinforcement, obtained in the serial maze learning where each stage was separately reinforced. The assumption was made that secondary reinforcement does function in nonsense syllable learning by the method of anticipation. In this study of animal learning Hull was demonstrating the cumulative effects of reinforcements and his explanation was dependent upon measures reflecting progress in learning. The previous studies of the effect of the remote associations involved measures of the error responses.

As a partial summary of the review of the literature up to this point, several conclusions can be noted.

1. Serial position effects have been observed under a great variety of experimental conditions.
2. Although no completely satisfactory account of the phenomenon is available, there is agreement that interference or inhibitory effects are present and that inhibition is casual to the bow-shaped serial position curve.
3. The presence of inhibitory potentials can not be directly observed but must be inferred from certain operationally specified indices of inhibition.
4. The assumed inhibitory potential occupies a vital position in the theory of rote learning as formulated by Hull and his

associates.

Reminiscence. It was in regard to reminiscence that Hull provided additional information on the relatively rapid dissipation of the inhibitory potential.

Hull (14), as a result of his analysis of rote learning, made several deductions which were later confirmed by experimental tests. One of his most interesting predictions was related to a class of phenomena that has been termed reminissence by Ballard (13, 20). Hull's prediction was that with a short time interval between the last learning trial and the recall trial, the middle of the list should show an increment in the curve of retention. This was based on the assumption that inhibitory tendencies disappear more rapidly with time than do excitatory tendencies. Consequently, there should be a spontaneous recovery of effective reaction potential during the rest period.[1]

Ward (31) and later Hovland (10) developed a procedure which did demonstrate the reminiscence effect after a short delay period. Hovland obtained the reminiscence effect following one presentation of a twelve nonsense syllable list as well as after the learning had progressed to a criterion of seven correct anticipatory responses on any one trial of the twelve syllable serial list. The experimental evidence indicated that the optimal interval for the recovery of the effective reaction potential is approximately two minutes. That is to say the maximum rate of the reduction of the inhibitory potential occurs within the first two minutes following the last serial learning trial. The importance of this supposed

[1] Hull's formal prediction was stated in Theorem XXXV, Corollary 1 in the 1940 publication (17, p. 257.)

constant is demonstrated in the experimental results and described in Chapter III.

Variations in procedure from that used by Hovland by later researchers,[1] however, have not always been successful in producing the reminiscence phenomena. The major variables tested have been meaningful material as against nonsense syllables, rate of presentation, length of interlist interval, and degree of rehearsal between learning and recall. Buxton and Ross (4) report findings that neither the rehearsal variable nor whether the syllables are spelled or pronounced is of crucial importance in determining the reminiscence effect. Melton and Stone (21) using meaningful material in the form of dissyllable adjectives were unable to demonstrate reminiscence. Noble (22) in attempting to account for the difference between the Ward-Hovland and the Melton-Stone results, established that variations in stimulus meaning are the crucial factor. He duplicated Hovland's procedure in all major respects other than in his use of trisyllable adjectives. His results were in conformity with the expected serial position effects but failed to reveal reminiscence. Noble interpreted his results as not being in disagreement with the Yale findings. He explained the absence of reminiscence by postulating that the increments of interference are greater during the learning of nonsense syllables than in learning meaningful materials.

Although the present status of the reminiscence phenomena is somewhat vague, we may conclude that the experimental evidence indicates that (1) the effects are most likely to appear when nonsense syllables are learned under conditions of massed practice to a criterion short of complete mas-

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[1] Noble (22) reviews the major findings of the recent studies.

tery; (2) at present the dissipation of inhibition explanation, contained within Hull's theory of rote learning, may be viewed as one of the more adequate explanations available; (3) for the purpose of our study, the inhibitory potential may be assumed to undergo its greatest loss of strength within a period of a few minutes following the terminal learning trial.

Hull, in defining the inhibitory potential, stated that it is not directly observable and can be demonstrated only by its effects. The indices which have been used for this purpose are the reminiscence effects and the characteristics of the learning process within the serial learning situation itself. For the latter index, three primary indicators have been used (17) to indicate inhibitory effects: 1) error curves, 2) acquisition curves for individual items, and 3) curves of the oscillation of response between the first correct and the last incorrect response. It is believed that the experimental technique used in the present study offers a far more compelling demonstration of the real presence and the action of such hypothetical inhibitory potentials.

Our brief historical sketch has indicated considerable controversy existing as to the sufficiency of these available indices of inhibitory potential. Further information on this problem would be of definite value. One of the purposes of the present study now being presented was to partially satisfy this need. An indicator of the effects of the inhibitory potential, capable of being operationally defined, would be available if in a learning situation in which the development of inhibitory effects is controlled, the presence of previous, experimentally induced inhibitory effects can be demonstrated by its influence in the current learning situation. From Hull's application of his theory of rote learning to the reminiscence phenomena, it may be assumed that the inhibitory potential continues to operate for several minutes following the terminal learning trial.

Transfer of Training. What is actually involved in the current study is the transfer and generalization of the inhibitory potential effects from the learning situation in which they developed to a second learning situation. Since this concept of transfer is somewhat unique, a brief review of this area of research appears to be desirable.

The learning of any new task is built upon a foundation of previous acquisitions. The study of the effect of a previous learning upon the proficiency of a subsequent learning of some task is conventionally referred to as transfer of training (13, p. 659). The effect of the previous acquisition may either serve to retard or to improve the new learning. The former result is termed negative transfer effect, and the latter is termed positive transfer effect.

The terms generalization and transposition, along with transfer, also have been used to denote the phenomenon that the way an organism learns to respond may be carried over from one learning situation to another. Transfer is the oldest term and primarily describes the carry-over of skills, memories and capacities. Generalization and transposition are of a more recent vintage, the former developed from the studies in conditioning. The terms generalization and transposition are applied when the carry-over from the first to the second learning situation involves some type of pattern or relationship. The phenomena described by these several terms, however, are closely related. The present study tested the carry-over to both identical and similar items, thereby including both transfer and generalization.

As we have seen, transfer effects can either be positive or negative. It is usually assumed (13) that the clearest understanding of transfer and the most meaningful basis from which to predict transfer effects result from an analysis in terms of stimulus and response factors. Several frequently quoted generalizations are derived from an analysis of this nature. (1) Where responses remain constant and stimuli are similar, positive transfer effects and stimulus generalization can be expected. This generalization when applied to verbal materials has been termed "law of assimilation" which states that each new stimulating condition tends to elicit the response which has been connected with similar stimulating conditions in the past. (2) When transfer is studied with identical stimuli but with varying responses, negative transfer effects are usually obtained.

The terms, proactive and associative inhibition, have also been used to refer to the phenomenon of negative transfer effects. The earliest formal statement of this generalization was the Muller-Schuman law of associative inhibitions: "when any two items, as A and B, have been associated, it is more difficult to form an association between either and a third item, K" (13, p. 665).

A statement of the entire generalization was made available by the Wylie hypothesis (20, p. 442), "the transfer effect is positive when an old response can be transferred to a new stimulus but negative when a new response is acquired to an old stimulus."

Gibson (6) examined the effect upon transfer of varying both stimuli and responses. In the second learning task her subjects learned new lists made up of entirely different responses but with stimulus items varying from identity to considerable dissimilarity. Her results indicate that the learning of the new material becomes more difficult with greater similarity of stimuli.

There is some indication that it is the response condition which determines the direction of the effects of stimulus similarities. Robinson (27) is of the belief that the importance of stimulus generalization in verbal learning has been over-emphasized while the value of response generalization has been under-emphasized. She reports the absence of transfer when only the stimulus conditions are varied but when the response conditions are varied transfer does occur regardless of whether or not the stimuli have been varied. The greater the similarity of the responses, the greater the transfer.

In a very recent study Underwood (30), predicting from the theory of response generalization, demonstrated that positive transfer, or associative facilitation, in paired-associates learning is directly related to inter-list response similarity as well as the degree of first-list learning.

Frequently referred to studies which deal directly with this problem are those of Yum (35) and Bruce (2).

From the very brief, preceding discussion we may note that transfer, or more specifically transfer of training, has been primarily concerned with the influence of previously acquired skills, habits, modes of response, and principles, upon subsequent learning situations. In order best to predict the direction of the transfer effects, i. e., whether they will be positive or negative, an analysis of the two learning situations is made in terms of the stimulus and response factors involved, as was done by Robinson (27). However, in the present study the transfer or carry-over from the first to the second learning situation involves a potential quite dissimilar from the content of the usual transfer study. Whereas the investigations of transfer effects considered the overall facilitation or interference observed in the second learning task, the major interest in the current study of transfer is in the differential difficulty of items in the same task which were associated with different amounts of inhibitory potential in a previous task.

An early but related area of investigation to the current problem was the work done in reference to the concept of transfer of fatigue. Robinson (25, p. 125) in discussing work decrements, stated in his seventh principle, "The work decrement of a given S-R connection is relative to the decrements which have developed in other S-R connections." Bills and McTeer (1, p. 24) in their study on transfer of fatigue a few years later commented, "Transfer of fatigue in mental work is a well recognized concept." However, the experimental basis for this observation was extremely meagre and to a large extent drawn from previous work that had been anectodal in nature. The purpose of Bills and McTeer's study was to test the hypothesis that fatigue transfer is proportional to the number of identical elements between the two tasks involved. The experimental work task consisted of writing letter sequences. The standard condition was writing ABC continuously for one minute period. The test conditions consisted of writing letter sequences in which the number of letters identical with the standard was varied from being completely similar to being completely different. Their results did substantiate their hypothesis i. e., the greatest transfer of fatigue, as measured by the decrement in work performance, occurred when the standard (initial) and comparison tasks were identical and the least effect appeared when the two tasks had no elements in common.

Further work in the area of transfer of fatigue has been concerned with the problem of physiological fatigue and related to that of bilateral motor transfer. The writer is of the opinion that the concepts involved in these studies along with the findings are not pertinent to the present project.

Before terminating the review of the literature one further relevant study should be noted, that of Riess (24). His research was based on the previous work by Razran in semantic conditioning (also known as mediated generalization). Razran (23), after establishing a conditioned response in his subjects to salivate to specific meaningful words, obtained a generalization of this response to synonyms and homophones of the original stimuli. Using groups of school children who differed only in chronological age, Riese conditioned them to verbal stimuli and then tested for generalization to homophones, antonyms, and synonyms. For the youngest group, age range of 7 - 11 years, he found that the greatest amount of transfer was to the homophones while the synonyms showed the least amount of transfer. The reverse was found for the oldest group, high school age, in which the synonyms exhibited the greatest degree of generalization and the homophones the least. Apparently the perception of the relationships existing between synonyms or antonyms involves a more advanced level of symbolic processes than is necessary for homophones. The development of this aspect of intellectual functioning in relation to chronological growth is reflected in the selection of items for intelligence testing. For the purpose of this review the pertinent fact is that generalization between words that were phonetically similar has not only been demonstrated, but found to occur most readily with children of the elementary school age.

SIGNIFICANT ASPECTS OF THE STUDY

In this section the significance of a study of this nature will be evaluated in terms of the conclusions drawn from the historical introduction to the research. The significance of positive or negative findings to the various theoretical issues previously discussed will also be considered here.

In the literature on serial position effects we have encountered evidence that the phenomenon described by the bow-shaped position curve of rote serial learning has been observed under so great a variety of experimental conditions that the term "universal" has been applied. Although no negating evidence was located in the literature, the results of the initial phase of this study may provide some indication of whether serial position effects occur with pre-adolescent subjects. This study will test the frequently applied assumption that the position effects do occur with subjects of this age group. Negative results would present a serious problem for all known theoretical accounts of serial position effects, since they all involve concepts applicable to any subject capable of serial rote learning. Since there is a high probability that serial position effects will be present in the serial learning task, negative results would justify a critical evaluation of the syllables and the experimental procedure.

The two major theoretical explanations available to account for the serial position effects were discussed in the historical review. There is agreement between both positions that interference or inhibitory effects are present and that inhibition is casual to the bow-shaped serial position curve. By testing the hypotheses that the inhibitory effects transfer and generalize, this study may provide further substantiation and understanding of the inhibitory potential. However, this study is not a critical test of either of the two theories. The absence of transfer will not serve to refute either Foucault's formulation involving proactive and retroactive inhibition or the Hullian interpretation based upon an assumed inhibitory potential. Neither theory is based upon the assumption that the inhibition does or should transfer out of the learning situation in which the effects are manifested, and that it does is one of our major experimental hypotheses.

Positive results in this investigation may provide additional support for the concept of inhibition as used in serial learning but the results will not provide, in any direct manner, the necessary information with which to indicate the theory that best accounts for the phenomenon in question.

The current investigation was planned, in the greater part, within the theoretical framework of Hull's system of serial rote learning. The decision to use Hull's formulations as the basis for this study reflects the limited scope within which Foucault's explanation operates. The major contribution of this study to the theoretical explanations of the serial position effects will be, if positive results are obtained to support the characteristics ascribed to the inhibitory potential by Hull.

Hull's theory of serial rote learning also provides an explanation for the Ward-Hovland reminiscence effect in terms of the dissipation of the inhibitory potential. The experimental condition of time may provide results capable of being integrated with the findings on reminiscence.

As described in the historical review, Hull developed a system of total adaptive behavior comparable to the system of serial rote learning. The concept of an inhibitory potential also is used but based upon a group of assumptions quite different from those in his theory of rote learning.

In the review of the literature we were unable to locate any direct previous studies demonstrating the transfer of a negative potential. The work of Bills and McTeer was related but involved concepts quite different from that of the inhibitory potential.

In the light of these factors, the present experiment is believed to be of significance.

CHAPTER II

EXPERIMENTAL PROCEDURE

In general outline, the procedure followed in the present investigation was to have groups of subjects learn, to partial mastery, a serial list of nonsense syllables. Following the serial learning each group, under the specific conditions for that group, learned pairs of nonsense syllables in which the stimulus member of each pair was related in a predetermined fashion to the syllables in the original serial list. The learning was measured throughout its course.

Subjects. The subjects used in this experiment were 48 elementary school children, of Arlington School, P. S. 234 in Baltimore, Md., with which the experimenter was associated. The subject sample had been selected from a total population of approximately 1900 students who were enrolled at the school. The subjects were selected on the basis of several qualifications so as to form a relatively homogenous sample.

Inter-subject similarity was desired since the study was designed to investigate syllable behavior rather than subject behavior. Consequently, variations among subjects as to learning ability, academic achievement, and interest or motivation to excel on intellectual tasks were partially controlled in the selection of subjects.

Analysis charts of each class prepared semi-annually were used in selecting a population of 200 children who satisfied the following requirements; fourth to sixth grade placement, minimum I. Q. of 112, reading ability in the top quartile for his grade, and rated by the previous two teachers as superior in "cooperativeness and interest."

The members of this population of eligible subjects met with the experimenter, in groups of twenty, for informal orientation meetings. At this time the exposure apparatus, sample nonsense syllables, and a brief discussion regarding how "learning can be studied scientifically" were presented. The children were told of the standards that were used in selecting them as potential subjects for a study that was to be conducted. They were also given a brief explanation of the concept of "random selection" and how it could be applied to the final selection of the sample of 48 subjects needed for the study. Before being given an opportunity to indicate whether they desired to be in the group from which the final sample was to be drawn, the need for the materials to be kept in strict confidence was discussed and stressed. Opportunity for questions was provided but no information as to the actual purpose or the specific nature of the experiment was disclosed. The children then individually reported whether they desired to serve as subjects. From the total group of 200 seven requested to be excluded.

The remaining 193 names were then alphabetically ordered and assigned ordinal numbers. These numbers were used with a table of random numbers (29) to select a sample of 48 subjects and supernumeraries in the following manner.

Each subject was assigned to a specific cell in the experimental design as he was selected by the use of the random numbers. Ah 8 by 6 table was drawn with the eight columns representing the eight orders of presentation for the learning of the serial list and the six rows representing the six paired-associate learning conditions. As the subjects were drawn, their names were entered into the table in the order shown in Table XVIII of the Appendix. The only restriction placed on the selection was that there were an equal number from each sex in each experimental group. This procedure was repeated two additional times so as to obtain two alternate subjects for each cell in the table.

Table I presents the characteristics of the forty-eight subjects that were employed in the study.

TABLE I

Final Subject Sample Characteristics

Measure	Mean	S. D.	Median	Range
Chronological Age	126 mos. (10-6)	2.75		111 - 142
Intelligence (Kuhlman-Anderson I. Q.)	122	6.3		112 - 133
Grade Placement			5-A	4-A - 6-A
Reading Grade Level (Standard Ach. Test)	7.6	1.8		5.0 - 10.5

Apparatus. The same apparatus was used for both the serial and the paired-associate learning. This is shown in Figure I. Essentially, it consisted of a wooden frame, backed with a masonite material. A rigid support for the frame was provided by a wide wooden base to which the frame was bolted. Rising from the top of the frame to a height of 12 inches was a black cloth screen mounted on #6 gauge wire. A half inch slot, open only at the top but extending the entire length and width of the frame was located between the frame and the masonite back. The entrance to the slot from the top of the frame was hidden from the subject's view by the cloth screen. As needed, the cards containing the material to be learned were dropped into the slot for presentation to the subject.

Hinged to the top left side of the wooden frame was a plywood flap.

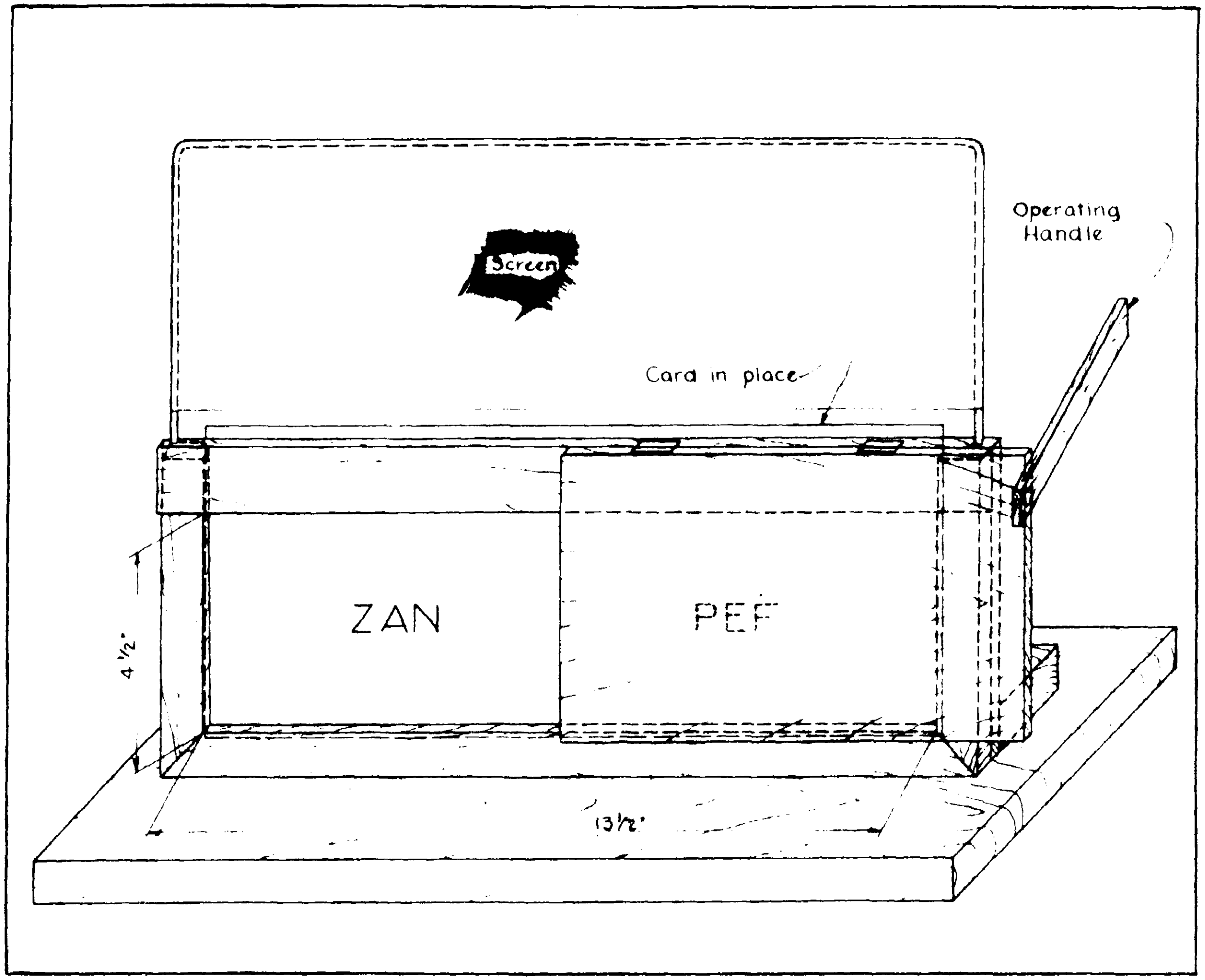

FIGURE I. Apparatus.

In the down position this flap completely covered the left side of the frame and its contents. This flap could be readily raised by a slight pressure of the hand on the operating handle. With the flap in this position, the entire contents of the frame were visible to the subject. Rubber strips on the flap permitted the rapid but smooth return of the flap to the down position by the simple technique of releasing the downward pressure of the hand on the operating handle. When only the left side of the frame was to be used, as during the entire serial learning, the flap was kept in the down position. For the paired-associate learning, the flap was down while the stimulus was presented and was then raised to expose the response member along with the stimulus member.

The cards that were used in conjunction with the exposure frame were 7 X 13 3/4 inches in size, constructed of three-ply white cardboard. On each card was lettered either a pair of nonsense syllables or a letter-number combination. One card contained only a plus sign on the left side of the card and was used as the cue for the serial learning lists. A blank card was also used and was visible between learning trials. A total of 31 cards, excluding duplicates and sample cards, were used in the study. The characters on the cards were 1/2 inch high and drawn with black India ink. To insure the conformity of the characters, a lettering set was used.[1] When presented in the frame, the syllables appeared centered in both halves of the frame..they could be readily recognized at a distance of 15 feet from the frame.

Since the exposure apparatus was manually operated, a convenient and reliable time source was needed. An electronic metronome,[2] preset to

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[1] Template #500CL with a #6 pen contained in the Leroy Lettering Set, manufactured by the Keuffel & Esser Company, New York, N. Y.

[2] METRONOMA, manufactured by the Crystal Research Laboratory, Hartford, Conn.

provide one audible beat each second, was used. The volume of the metronome was reduced to a level that was clearly audible to the experimenter and yet not distracting to the subjects. When specifically questioned after the study, the majority of subjects attributed the sound to a desk clock that was in the room. Only one subject considered it as an annoyance.

All responses of the subjects were recorded verbatim by the same recorder[1] during the entire study. Work-sheets were used for the recording of the data. Each work-sheet contained, prior to the subject's arrival, the subject's identification information, materials to be learned, sequence in which the material was to be presented, and experimental condition.

The study was conducted in a 7 by 9 ft. room, containing two large windows and relatively free from external noises and distractions. The subject sat directly in front of the apparatus with the light from the windows coming in over his right shoulder. The experimenter sat behind the apparatus and in that position could not be seen by the subject. The recorder sat behind and sufficiently to the left of the subject so as not to be visible to the experimenter. At this position she was able to hear all of the subject's responses, observe the apparatus, and inform the experimenter when the various pairs had been learned to the criteria.

<u>Learning Materials.</u> The outline of activities for all subjects was as follows:

practice learning -- serial learning -- paired-associate learning.

Five pairs of letter-number combinations were learned in the practice stage. The letters, the numbers, and the combinations had been selected in

1 Mrs. Jean Liebensberger faithfully served as the recorder.

a random fashion and were the same for all subjects. They are shown in Table II.

TABLE II

Pairs used in Practice Learning Stage

Pair	Stimulus	Response
1	R	5
2	S	7
3	D	9
4	F	4
5	H	2

The material that was used in both the serial learning stage and the final paired-associate learning stage is shown in Table III. Twenty-six of the 32 nonsense syllables in Table III have appeared in previously published lists (7) of nonsense syllables having low associative value. That is, these syllables do not tend easily to suggest meaningful words. The remaining six syllables in Table III were approved by six judges as not appearing to be of high associative value. In the experiment, the nonsense syllables were pronounced and not spelled aloud. This procedure was in accordance with that of Hovland (9, 10, 11).

The nonsense syllables in the first column of Table III served a dual purpose; they were the list used by all subjects for the serial learning and were the stimulus members of the paired-associates for experimental Groups A and D. The syllables in the second column were chosen as being phonetically similar to those in the serial list and were learned as stimulus members in the paired-associate learning by Groups B and E. The third column contains the syllables that were believed to be physically similar

TABLE III

Nonsense Syllables used in Serial and Paired-Associate Learning

Stimulus Members of Paired-Associates: Original *	Related		Changes in Original Syllables to produce Related Syllables		Paired - Associate Response Member
Condition A & D	Condition B & E (Homophones)	Condition C & F (Phy. Sim.)	Condition B & E (Homophones)	Condition C & F (Phy. Sim.)	
FEX	FAX **	FEM **	Vowel	Both consonents	BUV **
TOJ **	TUJ **	MOG	Vowel	Both consonents	YAD **
PEJ **	DEJ **	JEP **	1st. cons.	Cons. reversed	WOB **
BIK	BIQ **	KIB **	2nd. cons.	Cons. reversed	PAF **
MIB **	MIP **	MIF **	2nd. cons.	2nd. cons.	KEV **
VOF **	VOV **	VUP **	2nd. cons.	Vowel & 2nd cons.	TAH **
ZET **	ZED **	ZAL **	2nd. cons.	Vowel & 2nd cons.	NIZ **
COZ	KOZ	CAX **	1st. cons.	Vowel & 2nd cons.	LEB **

* Syllables used for the serial learning

** Contained in published lists of low associative value (7) to those in the serial list and were learned as the paired-associate stimulus members by Groups C and F. For each trio of syllables shown on the same row of the first three columns the same paired-associate response member was used. They are contained in the last column of Table III. The fourth and fifth columns indicate the location of the change in the syllable of the first column required in order to obtain the related similar forms shown in the second and third columns.

Procedure. Prior to each subject's entry into the experimental room all cards that were to be used in the three learning situations were arranged in their proper sequence for that subject. The same was true for the data sheets that were to be used.

The practice learning stage served to acquaint the subject with the experimental situation and to reduce variability due to difference in understanding the tasks and the instructions. The subject, after being comfortably seated and given an opportunity visually to examine the room, received the following initial instructions.

> At the last meeting that we had I told you a little bit of what we are going to do today. Do you remember the pairs of letter-number combinations? ______. We will work with that type of combination first. I have here a series of letter-number combinations, similar to the first group, and your job will be to learn them. Each pair is on a card of this type which fits into the frame. (Demonstration) The pairs will be learned in this manner. You will be shown the left half of the card on which you will see a letter; after several seconds this cover will be raised showing the right half of the card with the number that goes with the letter. During the time that only the letter is shown, you will try to remember the number that goes with it to complete the pair. You will say this number aloud before I raise the flap. You will have an opportunity to check your memory when the flap is raised. During the first few trials many of your answers may only be guesses, but tell us your guesses anyway, even if you are sure they are wrong. Your wrong answers can be important as well as your right answers. If your answer was wrong or if you couldn't give it before this flap was raised, then be sure to say the correct answer aloud when you see it.
>
> The first time that we go through the list of pairs, you simply watch them but do not give any answers, but with the

beginning of the second time through the list, you will try to 'beat the flap' by giving your answer aloud before I raise this cover. Any questions?

The five pairs of letter-number combinations were then presented in the exposure apparatus. The method and sequence of presentation was identical with the procedure to be used in the paired-associate learning stage. The stimulus was presented alone for three seconds followed by the stimulus and response together for three seconds. A six second interval elapsed between each complete trial. The method of adjusted learning (28) was used with the criterion of two successive correct responses. As each pair was learned to that level of mastery it was removed from the group. This continued until all of the pairs were learned.

In order to simplify the presentation for the experimenter and to equate the order of presentation for each pair, a systematic order of presentation was used. This is shown in Table IV.

TABLE IV

Order of Presentation for the Paired-Associates

Order	Presentation Sequence				
I	A	B	C	D	E
II	C	E	D	B	A
III	D	A	B	E	C
IV	B	C	E	A	D
V	E	D	A	C	B

During the learning of the pairs, each card after being exposed was returned to a retaining bracket in the rear of the apparatus, in an upright position and in the order that it had been presented. At the completion of each trial, the middle card, in a pack of five or three cards, would be selected as the first card to be presented in the next trial. The remaining cards would then be presented in the reverse order from that in which they had been stacked. In a pack of four cards, the third card would be presented first and the remaining three cards in the same order as described above.

At the end of each trial, the recorder would indicate to the experimenter by a prearranged signal which cards, if any, were to be removed from the pack. Each card had an identification tab on its reverse side. The practice stage was terminated when each pair had been learned to the criterion. The average time required for this stage was approximately three minutes.

Following the practice stage, the subject was sent to the water fountain located in the hall outside of the room and permitted to go to the lavatory if he so desired. While he was out of the room any preparations for the following learning stages were accomplished. The serial stage followed the practice stage by approximately four minutes.

The following instructions were given to the subjects prior to the serial learning.

> Your cooperation has been excellent. We are now ready for the second part of the study, but this time there is a slight change in the procedure.
>
> First, let me introduce you to a nonsense syllable (demonstrate). It consists of two consonents with a vowel in the center. We call it a nonsense syllable since it really has no meaning, but it can be pronounced and it can be learned.
>
> The nonsense syllables will be shown to you in this frame, but this time we will not use the flap at all since you will see the syllables in the left half of the frame. The syllables will be presented individually and in succession, that is, one after the other. The syllables will always be in the same order. You will learn the list of syllables by telling us each time that a syllable is shown, what will be the next one to follow it. Before the first syllable of the list you will be shown a plus sign, and a blank card will follow the last syllable of the list. Each syllable will be shown for a short time and during that time you are to pronounce aloud what will next appear in the frame. Here again, your wrong answers can be as important as your right answers, so be sure to answer before the next syllable appears. If you answer is wrong or if you were too slow, give the correct answer when you see it.
>
> Let us go through the list together the first time. You

> watch each syllable very carefully while I pronounce them. Beginning with the second trial, you anticipate each syllable before it is shown. Any questions?

The serial list of eight nonsense syllables was presented at the constant rate of two seconds per syllable with a delay of six seconds between the last syllable and the cue syllable; the latter preceded the first syllable by two seconds. The serial learning was terminated when the subject gave five correct anticipatory responses from the possible eight responses. All responses were recorded verbatim.

An important experimental condition for the study of serial position effects is that the syllables be of approximately equal difficulty. If any one syllable is easier to learn than the others, either because of some intrinsic characteristic or as a response to its predecessor, it might be more easily learned regardless of its position in the list. In this experiment, although relative equality is the syllables used in the serial learning is assumed, an attempt was made to control the effects of any differences in associative value among the syllables. The eight syllables for the serial learning were arranged in eight different lists. The eight lists were so structured that each syllable occupied each position only once and followed each of the other syllables only once. The eight different lists are shown in Table V. In the serial learning stage each list was learned to criterion by six subjects.

Paired-Associate Learning. Two experimental variables were investigated in the terminal paired-associate learning; (1) two conditions of time between the serial and paired-associate learning, and (2) three conditions of similarity between the paired-associate stimulus member and the counterpart nonsense syllable in the serial list. A total of six groups were, therefore, necessary to investigate the six experimental conditions in order to estimate independency of effects.

TABLE V

Arrangement of the Eight Syllables used in Serial Learning in Eight Different Lists; Each List Contains the Same Syllables but in Different Positions and with Different Preceding and Succeeding Syllables.

Position	Lists							
	I	II	III	IV	V	VI	VII	VIII
1	FEX	MIB	BIK	PEJ	TOJ	VOF	ZET	COZ
2	TOJ	PEJ	VOF	FEX	MIB	COZ	BIK	ZET
3	PEJ	ZET	TOJ	MIB	COZ	BIK	FEX	VOF
4	BIK	FEX	COZ	ZET	PEJ	TOJ	VOF	MIB
5	MIB	COZ	FEX	TOJ	VOF	ZET	PEJ	BIK
6	VOF	TOJ	ZET	BIK	FEX	MIB	COZ	PEJ
7	ZET	VOF	PEJ	COZ	BIK	FEX	MIB	TOJ
8	COZ	BIK	MIB	VOF	ZET	PEJ	TOJ	FEX

The six experimental groups are shown in Table VI. The selection of the subjects for six groups has been described earlier in this chapter. In each of the six paired-associate groups there was one subject from each of the eight serial learning groups (see Table XVIII in Appendix). In conditions A through C, the paired-associate learning followed the serial learning by approximately four seconds. In Conditions D, E, and F, a twenty-four hour interval separated the serial from the paired-associate learning. For Groups A and D, the stimulus members of the five pairs for each subject were those nonsense syllables that he had encountered in Positions 2, 3, 5, 6, and 8 of the serial list. For the two Homophone Groups, B and E, the paired-associate stimulus members for each subject were phonetically similar to the syllables he had learned in Positions 2, 3, 5, 6 and 8 of the serial list. The stimulus members for the last two groups, C and F, were

TABLE VI

Experimental Groups in Paired-Associate Learning

Stimulus Form	Time	
	Immediate	24 Hour Interval
Identical	A	D
Phonetically Similar (Homophones)	B	E
Physically similar	C	F

physically similar to the serial syllables in Positions 2, 3, 5, 6, and 8 for each subject. The specific stimuli and responses for each of twenty-four available pairs were shown in Table III.

For each subject there were, therefore, five pairs of nonsense syllables to learn to the criterion. The pairs for any one subject were determined by the serial group and the experimental group to which he was randomly assigned. Since the eight original syllables had occupied a different position for each order of the presentation of the serial list, each syllable was learned as a stimulus member of a pair by five subjects from each experimental group.

A duplicate set of cards had been prepared for Group A so as to permit the immediate transition from the serial learning to the paired-associate learning. If this precaution had not been taken it would have been necessary to select the five desired cards from the pack that had been used for the serial learning and this could not be readily accomplished in the period of four seconds.

The subjects in Groups A, B, and C received the following instructions immediately following the serial learning.

> Now back to pairs, but this time pairs of nonsense syllables; during first trial I'll pronounce.

Groups D, E, and F, upon their completion of the serial learning receivéd the following instructions.

> Thank you very much for your excellent cooperation. That is all that we will do today. It is important that you tell no one about the syllables that you saw here today. Just forget them.

The following morning at the same hour the subject of D, E, and F was instructed to report to the experimental room. His instructions were similar to those received by the subjects in the other groups.

> Today we are going to do some work with nonsense syllables, but this time we will use pairs of nonsense syllables. During the dirst trial I will pronounce them for you.

For all subjects, the respective five pairs of nonsense syllables were presented in the apparatus at the rate of three seconds for the stimulus and three seconds for both stimulus and response together. Immediately following the first trial each subject was told,

> Now, you beat the flap by saying the answer before I raise the cover.

The sequence in which the pairs were presented during each trial was in accordance with the scheme shown in Table IV. In accord with the method of adjusted learning each pair was removed from the pack as it was learned to the criterion of three successive correct responses.

Each subject, upon the completion of the last learning stage was informally questioned as to his understanding of the purpose of the study, his awareness of the metronome, and the reason for keeping the nonsense syllables under strict confidence. The discussion on the latter point was maintained until the experimenter was quite certain that the subject would maintain the security.

Miscellaneous. The actual collection of the data occurred over a period of six weeks. Four mornings each week were used between the hours of 9:30 to 11:30 A. M. Every Monday morning of the six week period, the teachers were provided with a list of those children in their classes who were to serve as subjects during that week and the day on which they were to be seen. This permitted the respective teachers to plan her work for the week accordingly. Each morning, at 9:10, the experimenter was notified if any of the subjects for that day was absent from school. The supernumerary was then substituted. It was necessary to discard the results of the first learning stages for two subjects who were absent on the second morning.

Of the eight subjects seen each week, at least one was from each of the six experimental groups. The weekly schedule was as follows: Monday and Tuesday four subjects from Groups D, E, and F, at half hour intervals; Wednesday and Thursday, four subjects from Groups A, B, and C, at hour intervals.

There was no indication that any of the subjects had any knowledge of the materials prior to actually seeing them under the experimental conditions. During the last week of school, five weeks following the completion of the study, fourteen of the subjects, individually, inquired from the experimenter as to whether they could then tell their parents of their experience.

CHAPTER III

RESULTS

The serial and paired-associate learning tasks employed in this study were described in detail in the previous chapter. The purpose of the serial learning was to provide the assumed inhibitory potential, manifested in the serial position effects. The demonstration of the presence of inhibitory potentials was a primary requisite in designing a test of their transfer to a non-serial learning task.

The data obtained from the paired-associate learning stage provide us with some basis for conclusions regarding the major hypotheses: (1) that the inhibitory potential transfers from the serial learning process, (2) that the carry over would be maximum if the non-serial learning immediately followed the serial learning, and (3) that the inhibitory effects could be shown with syllables that were similar as well as those that were identical with the syllables employed in the serial learning.

This chapter presents the results and the discussion of both the serial and the paired-associate learning tasks. The trial by trial learning progress for each subject was analyzed in terms of error responses, correct anticipations, and correct-responses-minus-error responses. Measures expressed in terms of error responses were found best to reflect the course of the learning process for the specified purposes of this study. The measures and results presented in this chapter will be comprised mainly of error responses.

ROTE SERIAL LEARNING OF THE EIGHT NONSENSE SYLLABLES

Two measures of the serial learning will be presented and discussed in this section: (1) total error responses for all trials to criterion, and (2) the error responses occurring on the criterion trial.

The first measure to be discussed is the total error responses as a function of the ordinal positions in the list when the learning had progressed to the criterion of five syllables correct. The total, mean, and the standard deviation of error responses for each of the eight serial positions are shown in Table VII. The mean total error responses for each position is shown graphically in Figure II. (Page 41) The graph indicates the type of serial position effects that had been deduced by Hull and his associates (17) and validated by Ward (31) and Hovland (9, 10). The rank order of position according to the number of error responses locates the area of maximum difficulty (greatest number of errors) immediately beyond the center of the list. Positions 1 and 2 had the least number of error responses, and the last position in the list was easier to learn than the third position. Syllables in the sixth and seventh positions showed approximately the same amount of difficulty.

Table VII also presents the total error responses for each syllable regardless of position in the serial list. The assumed equality of the associative strengths does not appear to be substantiated since the most difficult syllable, VOF, showed 132 more error responses than the easiest syllable in the list, MIB. Notwithstanding this inter-syllable difference in ease of being learned the inter-position differences appeared in the direction predicted and in accordance with the bow-shaped curve of serial position.

The statistical analysis of the data was relatively involved as a result of the experimental design which permitted the elimination of the outstanding irrelevant variances in the analysis of variance. For each of the 48 subjects, error scores were available for the eight syllables

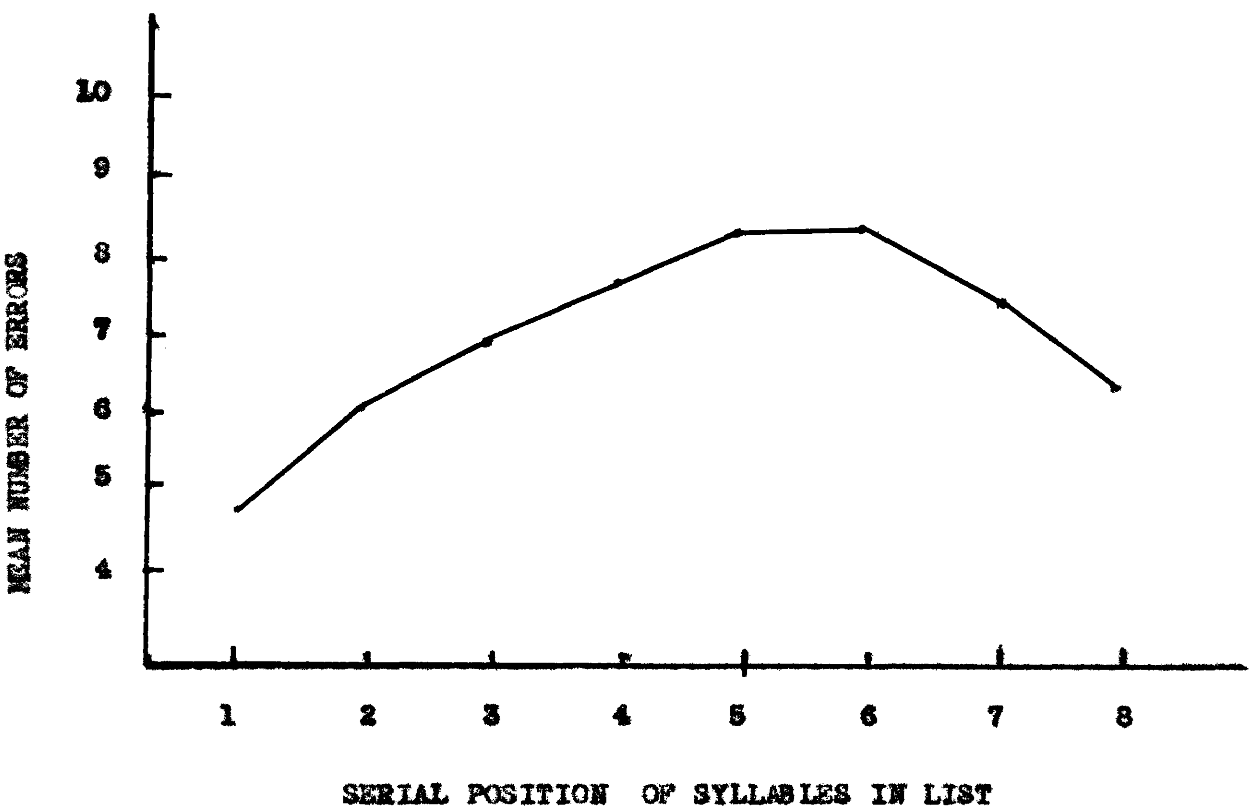

FIGURE II. Mean Total Errors for each Position During Serial Learning to Criterion.

TABLE VII

Total Responses for Each Syllable Listed According to the Position of the Syllable in the Serial List *

Syllables	Position 1	2	3	4	5	6	7	8	Sum
MIB	18	22	29	29	42	33	36	38	247
COZ	26	38	45	36	43	56	27	29	300
BIK	20	19	57	41	47	68	44	39	335
ZET	26	33	45	45	49	47	56	35	336
TOJ	27	45	42	57	58	49	30	32	340
FEX	37	44	37	49	42	50	66	36	361
PEJ	47	45	38	45	48	39	52	52	366
VOF	26	44	42	64	67	65	46	35	379
Sum	227	290	335	366	396	397	357	296	2664
Mean	4,73	6.04	6.98	7.62	8.25	8.27	7.44	6.16	6.93
S.D.	2.39	3.61	3.30	3.59	3.32	3.33	3.92	2.55	
Rank Order of Positions	1	2	4	6	7	8	5	3	

* Each syllable occupied a different position in eight counterbalanced lists (see Table V). Totals are for learning trials to the 5/8 criterion for the 48 subjects. Syllables are listed at the left in their rank order of ease of learning.

in the eight positions of the list, providing a total N of 384, with 383 available degrees of freedom. For the purpose of the analysis, the subjects were divided into groups of eight subjects. Each group of subjects comprised an 8 x 8 Latin square, with the columns representing the 8 positions, rows representing both subjects and a specific order of presentation, and the cell entries representing the 8 syllables. With 48 subjects there were six replications of the square. The complete design is presented in Table XIX of the Appendix.

Prior to the analysis, Bartlett's test (29) of the homogeneity of variance was applied. A corrected Chi-square value of 48.35 was obtained which, with 47 degrees of freedom, indicated that the null hypothesis in respect to differences between group variances could only be rejected at the 20% level of confidence, and thus offered no basis for rejection.

An analysis of variance which permitted the separation of the variances attributable to both the independent and the correlated observations was then performed. The results of this analysis are shown in Table VIII.

For the total sums of squares between individuals with 47 df., two estimates of variation were obtained: (1) the variance based upon 7 df. and due to the differences in the orders of presentation, and (2) the residual between individuals with 40 df. The latter was used as the error measure to test the significance of the mean square attributable to the different orders of presentation. The resulting insignificant F-ratio indicates that we may not reject the null hypothesis concerning differences among the eight orders of presentation.

The remaining sums of squares with 336 degrees of freedom was based upon observations of the same subjects, i. e., correlated observations. Of this variation within individuals, the portions attributable to two independent variables were identified: (1) the mean square for position

TABLE VIII

Analysis of Variance of Total Error Responses for the Serial Learning

Source of variation	df.	Sum of squares		Mean square	F	F (.05)	F (.01)
Independent observations:							
Order of presentation	7	334.00		47.71			
Residual between individuals (error)	40	2119.25		52.48			
Total between individuals	47		2453.25				
Correlated observations:							
Position	7	503.92		71.99	14.17**	2.39	3.36
Syllables	7	261.17		37.31	7.34**	2.39	3.36
Residual (error)	322	1636.41					
Total within individuals	336		2401.50				
Total for serial learning	383		4854.75				

** Statistically significant beyond the 1% coefficient of risk.

effects, and (2) the mean square for differences between the eight nonsense syllables, both based upon 7 degrees of freedom. The residual mean square based upon 322 df. was used as the error estimate. The F-ratios for both the position effects and the inter-syllable differences were fully significant beyond the .01 level of confidence. The null hypothesis applied to the mean position differences listed in Table VII may not be accepted at this level of confidence. The bow-shaped curve of the serial learning shown in Figure II can therefore be attributed to position effects involving the presence of the assumed inhibitory potential. However, the initially assumed equality of the associative strengths of the nonsense syllables was not confirmed. At this level of confidence, the null hypothesis may not be accepted.

Whereas the above significant differences between mean position scores for the measure of total error response offers credence to the presence of an inhibitory potential during the entire serial learning, that measure does not specifically indicate whether the inhibitory effects were operating in the criterion trial of the serial learning and immediately preceding the paired-associate learning. A second measure was therefore employed, error responses on the last or criterion trial. Table IX presents the total and mean errors along with the standard deviations for each position on the last trial. Also listed are the rank orders of the positions according to the error responses. The means of the error responses for each position are shown graphically in the lower curve in Figure III. (Page 46) The position effects may be readily observed from the bow-shaped curve. Positions 4, 5, and 6 had the greatest number of error responses with the fifth position, immediately beyond the center of the list, as the most difficult position in the list. It is interesting to note that on the criterion trial none of the 48 subjects

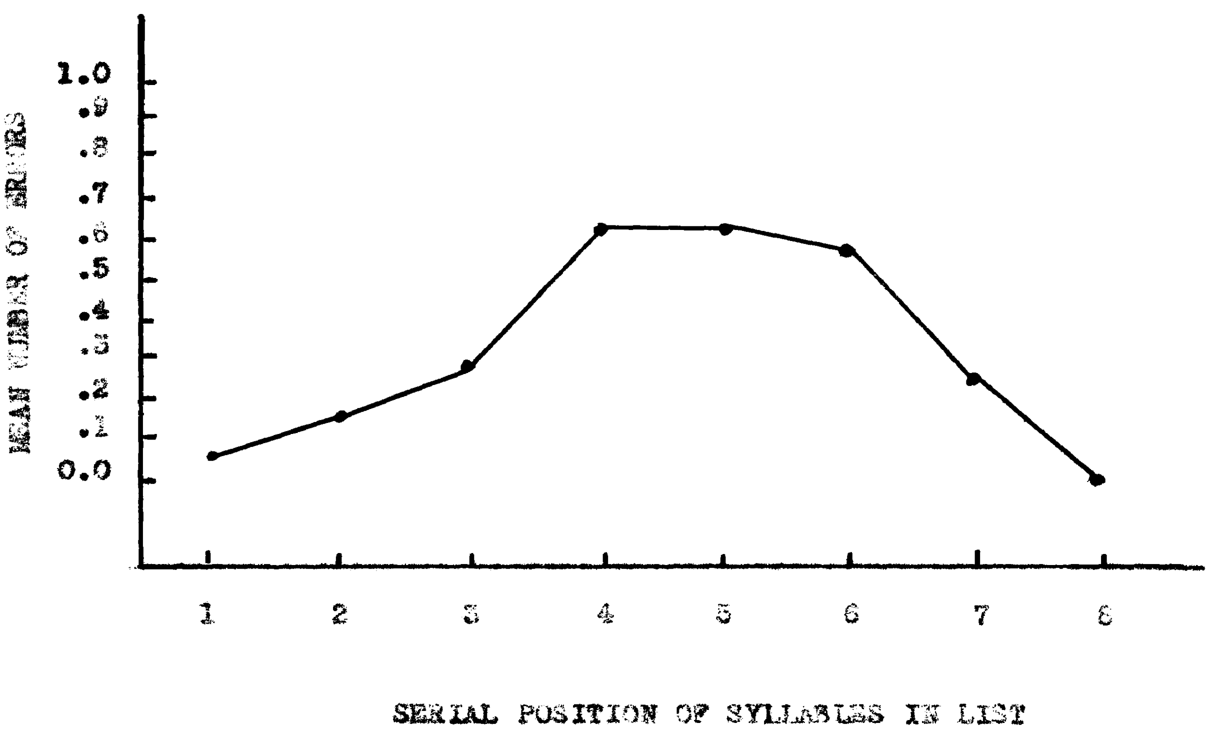

FIGURE III. Mean errors for each position on criterion trial of serial learning.

TABLE IX

Mean and Standard Deviation of Error Responses on the Criterion Trial

	Position in the serial list							
	1	2	3	4	5	6	7	8
Mean	.06	.17	.29	.64	.67	.60	.23	.00
S. D.	.08	.16	.81	1.56	1.58	1.47	.65	.00
Rank Order	2	3	5	7	8	6	4	1

failed to anticipate correctly that syllable which occupied the last position in the list.

An application of Bartlett's test for homogeneity of variance resulted in an uncorrected Chi square of 4.03. For this value of Chi square with 7 df the null hypothesis in respect to difference between position group variances could only be rejected at the 20% level of confidence.

The results of the analysis of variance applied to these data are shown in Table X. The independent variable tested for significance was

TABLE X

Analysis of Variance for Criterion Trial Error Responses of Serial Learning

Source of variation	df.	Sum of squares	Mean square	F	P
Position	7	163.74	23.39	16.58 **	.01
Residual (Error)	56	79.02	1.41		
Total	63	242.76			

** Statistically significant beyond the 1% coefficient of risk.

the variance due to position effects based upon seven degrees of freedom. The error term represents the variability between subjects, orders of presentation and intersyllable differences. The latter variable was pooled with the subjects and orders after being found to be statistically non-significant. The variability attributed to position effects was found to be significant beyond the one percent level of confidence.

We may, therefore, conclude at a high level of confidence that the null hypothesis in reference to the position effects, for both measures of the serial learning, should be rejected. With this evidence of the presence of position effects, the necessary conditions from which to assume the presence of the inhibitory potential were satisfied. The test of the transfer of this inhibitory potential out of the serial learning situation in which it was developed will be discussed in the next section.

PAIRED-ASSOCIATE LEARNING

This section presents the results and the discussion of the six paired-associate learning conditions that were designed to test the hypotheses that: (1) the effects of the inhibitory potential can transfer out of the learning situation in which it was generated, (2) the greatest carry over would occur immediately following the serial learning, and (3) it would occur with similar as well as with the identical syllables that were involved in the serial learning process.

The six experimental conditions of the paired-associate learning permitted the investigation of the two primary experimental variables: (1) two conditions of time, either immediately following the serial learning or after an interval of twenty-four hours, and (2) three conditions of the form of the paired-associate stimulus member; identical, phonetically similar, or physically similar to the syllables used in the serial list.

The results of the paired-associate learning are presented in terms of error responses as was the case with the serial learning results.

The two primary measures that were used to analyze the process of the paired-associate learning will be discussed in this section. (1) Error responses in all trials including the last criterion trial and (2) error responses that occurred in the first four trials of the adjusted paired-associate learning situation. Both measures were applied to each of the six experimental conditions.

TABLE XI

Means and Standard Deviations of Error Responses Obtained during all Trials to Criterion for the Six Paired-Associate Conditions

Condition		Position in serial list occupied by identical or similar syllable as that of stimulus member				
		2	3	5	6	8
A- Immediate identical	Mean	4.1	5.2	6.4	9.4	7.0
	SD	4.90	2.73	4.83	7.78	6.68
B- Immediate homophones	Mean	8.4	7.4	9.1	9.0	7.2
	SD	2.84	3.37	6.63	4.33	2.86
C- Immediate physic. sim.	Mean	5.1	8.1	6.2	4.6	5.5
	SD	2.42	2.60	3.17	3.57	1.87
D- Delay identical	Mean	6.4	11.4	11.0	7.6	8.6
	SD	3.23	9.31	6.64	4.35	6.42
E- Delay homphones	Mean	8.6	6.4	7.6	9.4	8.2
	SD	5.02	3.19	4.17	3.61	5.45
F- Delay physic sim	Mean	11.2	8.5	6.4	6.7	8.0
	SD	3.61	5.91	4.54	3.26	5.10

SUMMARY TABLE (XI a)

Means					
1 - Immediate	5.87	6.91	7.25	7.67	6.50
2 - Delay	8.75	8.75	9.00	7.92	8.25
3 - Identical	5.25	8.20	8.70	8.50	7.80
4 - Homophones	8.50	6.90	8.36	9.20	7.70
5 - Physically sim.	8.65	8.30	7.30	5.85	6.75

Table XI presents the means and the standard deviations of error scores on all trials for all syllables in each of the five positions that each syllable or its counterpart had occupied in the serial list. Each mean entry was determined by the performance of eight subjects, with each subject learning a different pair of nonsense syllables for any one position entry.

Differences in position means in the direction predicted by the transfer hypothesis were obtained for Conditions A and B. In these two conditions, where the paired-associate learning immediately followed the serial learning, those pairs in which the stimulus counterparts had occupied a more difficult position in the serial list showed more error responses in the paired-associate situation. In Condition C, with the same time relationship as in A and B, this trend in differences between position means did not appear. In Condition D, in which the identical syllables also were used, those syllables immediately preceding the middle of the serial list appeared to be the most difficult to learn in a paired-associate situation twenty-four hours later.

The design of the experiment was planned so as to permit the use of the analysis of variance in the evaluation of these results shown in Table XI. However, an application of Bartlett's Test of the variance homogeneity for the 30 estimates of the population variance resulted in a Chi-square value, corrected, of 43.52. This value of Chi-square with 29 df permitted the acceptance of the null hypothesis only at a .04 level of confidence. Two alternate courses were available: (1) assume that the differences among the variance estimates were only sample phenomena, i. e. $C_M = 0$, and perform and overall analysis of variance or (2) analyze separately those conditions with homogeneous variances. Both courses were followed in the treatment of this measure.

Table XII presents the relevant data of the analysis of variance for the six experimental conditions. Position, time, and form were the three primary independent variables with 4, 1, and 2 degrees of freedom respectively. All interactions among these variables were also analyzed.

TABLE XII

Analysis of Variance of Error Responses During All Trials of the Six Paired-Associate Learning Conditions

Source of variation	df.	Sum of squares	Mean squares	F	F (.05)	F (.01)
Position	4	21.94	5.48	---		
Form	2	30.63	15.31	---		
Time	1	171.70	171.70	6.47 *	3.89	6.76
P x F	8	230.55	28.82	1.09	1.98	
P x T	4	42.41	10.60	---		
T x F	2	92.35	46.18	1.74	3.04	
P x F x T	8	204.25	25.53	---		
Within (Error)	210	5571.72	26.53			
Total	239	6365.56				

Only the variance attributable to the variable of time between the two learning tasks showed any statistical significance. All other variance ratios could be attributed to chance.

An analysis of variance was then performed for the differences between positions within each experimental condition. The variances, degrees of freedom, and the obtained F - ratios are presented in Table XIII. The within group variance was used as the error term in each instance. In none of the six experimental conditions was the variance due to position effects significant. We must conclude, therefore, from

TABLE XIII

Ratio of Position Variance Within Group Variance, Degrees of Freedom, and F for the Measure of Errors on All Trials

Condition	Variance	df	F	F (.05)
A- Immed. identical	30.94/36.96	4/35	---	
B- Immed. homophones	6.19/21.89	4/35	---	
C- Immed. phy. sim.	14.91/ 8.55	4/35	1.74	2.65
D- Delay identical	40.87/45.99	4/35	---	
E- Delay homphones	10.15/22.07	4/35	---	
F- Delay phy. sim.	21.72/23.74	4/35	---	

the results of this measure which reflects the learning process during the entire paired-associate learning situation that our hypothesis regarding the transfer of the inhibitory potential was not sustained.

In light of the fact that the overall analysis (see Table XII) had revealed that the variance attributable to the variable of time was significant beyond the five percent level of confidence, an analysis was done of the variance for each two conditions, immediate and delay, in which the same syllables were used as the stimulus members of the pairs. Further justification of this test was in the findings that the null hypothesis regarding the variance differences within each pair of experimental conditions could not be rejected at P equal to .20.

The major results of this analysis of variance are presented in TABLE XIV. The three sources of variation tested were position based upon 4 degrees of freedom, time with 1 df, and the interaction of position and time with 4 df. For each pair of conditions the error term used to test the significance of the independent variables was the within group variance.

TABLE XIV

Variance Ratios, Degrees of Freedom, and F's for the Three Conditions of Stimulus Syllable Form (Measure - Total Error Responses on All Trials)

Condition	Variance	df.	F	F (.05)	F (.01)
	Time Variance / Within Group Variance				
A and D - identical	137.81/41.47	1/70	3.32	3.98	
B and E - homophones	.80/21.98	1/70	---		
C and F - phy. sim.	140.45/16.14	1/70	8.70**		7.01
	Position Variance / Within Group Variance				
A and D	31.97/41.47	4/70	---		
B and E	12.34/21/98	4/70	---		
C and F	18.81/16.14	4.70	1.16	2.50	
	Position X Time / Within Group Variance				
A and D	36.09/41.47	4/70	---		
B and E	4.01/21.98	4/70	---		
C and F	17.82/16.14	4/70	1.10	2.50	

Only the variance attributable to the difference in the time of the paired learning for those pairs in which the stimulus members were physically similar to the original serial list was statisically significant (F of 7.01 being required for significance at the one percent level of confidence.) The variance ratios for position effects and for the interaction of position and time could be attributed to chance.

In the overall analysis of variance involving the measure of total errors to criterion (Table XII) the variance attributable to time was significant beyond the .05 level. The major contributor to this significant variable was the effect of time on the differences between the two conditions in which the physically similar nonsense syllables were used, (Table XIV). For all positions, the pairs of associated nonsense syllables were easier to learn when the learning followed immediately after the serial learning (Cond. C) than when the twenty-four hour delay intervened (Cond. F). This marked facilitation of the immediate learning could be interpreted as indicating a positive transfer of effect from the serial learning. In making this interpretation Condition F was considered as the control. Unfortunately no control was available from which to determine whether this positive transfer effect also was present in the twenty-four hour delay group.

A question meriting consideration at this point is the absence of this facilitation in Conditions A and B when compared with their delayed counterparts, D and E. Using Condition C as the control, one possible interpretation would be that the gain from positive transfer effects was offset by the presence of associative interference operating in both Conditions A and B. In the learning of the paired-associates in which the stimulus members were related to the previously learned serial list, the subjects were actually being required to form new responses to old stimuli or syllables similar to the old stimuli. If we were to assume a dimension of similarity for our triplets which served as the paired-associate stimulus members, the identical syllables would be at one end, the physically similar at the other end, and the phonetically similar over somewhere on the continuum between either end. Our results would then be similar to Gibson's (6) finding that when new responses are involved, the greater the similarity of the stimuli the more difficult becomes the learning of the new material. The physically similar stimuli of Condition C were sufficiently dissimilar to the serial syllables so as to minimize any associative interferance offsetting the positive transfer of training effects.

Error Responses During First Four Trials. Since so much of the research being done in psychology is explanatory in nature the most adequate measures often can only be determined after the data are available and a number of theoretically relevant measures are applied. The following measure analyzed the results of the early portion of the paired-associates learning process. This measure was based on the fact that the inhibitory potential, if present, should be at its maximum strength immediately following the serial learning.

The second measure that was used to study the effect of the serial learning upon the following paired-associate learning was the number of error responses occurring during the first 4 trials of the test situation. The application of this measure was indicated by Hull's thirteenth postulate (17, p. 67) which describes the reactive inhibition as dissipating rapidly in time. Support for this postulate was drawn from Ward's (31) data regarding the reminiscence effect in the recall of nonsense syllables. Ward's results indicated that the maximum dissipation of the inhibitory potential occurs within a period of two minutes following the terminal serial learning trial.

Under the experimental condition of immediate paired-associate learning in this study, the first four trials of the five nonsense pairs were completed within approximately 105 seconds of the last serial learning trial. If present, the inhibitory potential which was generated during the serial learning should manifest its maximum effects during the learning progress of the first four trials.

The means and standard deviations of the error responses during the first four trials for the six paired-associate groups are listed in Table XV according to the position occupied by the stimulus member in the serial learning. Each mean entry was based on an N of eight subjects with each subject having learned a different pair of nonsense syllables. The five mean values for each condition are shown graphically in Figure IV. (p.58) An inspection of the curves for the six experimental conditions reveals two curves, those for Conditions A and B, which have characteristics similar to the bow-shaped curves for serial position effects. The curve for Condition A is the most similar in that the point of greatest number of errors occurs at the fifth position while for Condition B the stimuli related to those encountered in the sixth position of the serial list were the most difficult to learn in the paired-associate situation.

The analysis of variance was used as the test of significance for the data presented in Table XV. A Chi-square value of 31.75 was obtained from Bartlett's test. This uncorrected value of Chi-square was evaluated with 29 degrees of freedom and indicated a probability of approximately .30. The data offered no evidence against the hypothesis of random sampling from a population with a common variance.

TABLE XV

Means and Standard Deviations of Error Responses Obtained During First Four Trials for the Six Paired-Associate Conditions

Condition		Position in serial list occupied by identical or similar syllable as that of stimulus member				
		2	3	5	6	8
A - Immediate identical	M	2.12	3.12	3.50	3.25	2.75
	SD	2.21	1.70	2.00	2.33	1.87
B - Immediate homophones	M	2.62	3.37	3.62	3.75	3.00
	SD	1.97	1.97	1.97	1.23	2.00
C - Immediate physically sim.	M	3.50	3.62	3.37	2.87	3.25
	SD	2.45	1.37	2.42	2.98	1.87
D - Delay identical	M	3.50	3.62	3.87	3.50	3.50
	SD	2.00	1.32	.94	2.45	2.83
E - Delay homophones	M	3.87	3.62	3.50	4.00	3.87
	SD	.94	1.37	2.45	.00	.94
F - Delay physically sim.	M	3.87	3.00	3.62	3.50	3.37
	SD	.94	3.74	1.97	2.00	2.42

SUMMARY TABLE

Means:	2	3	5	6	8
1. Immediate	2.75	3.37	3.50	3.29	3.00
2. Delay	3.75	3.41	3.66	3.67	3.56
3. Identical	2.81	3.37	3.72	3.38	3.13
4. Homophones	3.25	3.49	3.56	3.88	3.44
5. Physically similar	3.69	3.31	3.49	3.19	3.31

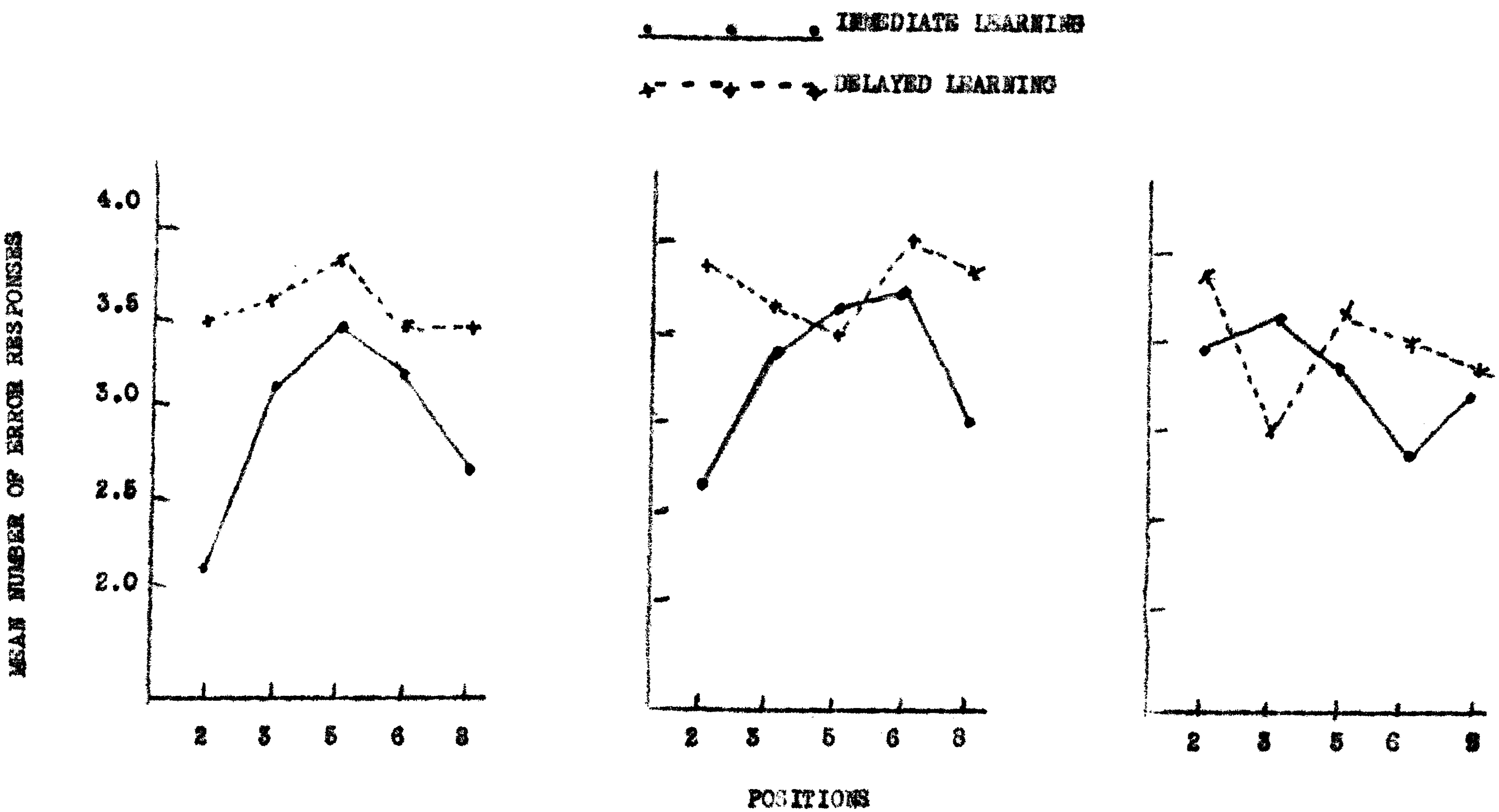

FIGURE IV. Mean error responses obtained during first 4 trials of the paired-associate learning for each group and according to the position occupied by the stimulus counterpart in the previous serial learning.

The relevant data from the overall analysis of variance for the results obtained in the first four trials are shown in Table XVI. The three primary variables were position with 4, time with 1, and form with 2 degrees of freedom.

TABLE XVI

Analysis of Variance for Error Responses Obtained During First 4 Trials of the Six Paired-Associate Conditions

Source of variation	df.	Sum of squares	Mean square	F	F (.05)	F (.01)
Position	4	3.50	.88	1.49	2.41	
Time	1	11.27	11.27	19.10**		6.76
Form	2	2.50	1.25	2.12	3.04	
P x T	4	6.96	1.74	2.95*	2.41	
P x F	8	5.64	.71	1.20	1.98	
T x F	2	2.60	1.30	2.20	3.04	
P x T x F	8	8.13	1.02	1.73	1.98	
Within (Error)	210	123.00	.59			
Total	239	153.60				

The variance resulting from the factor of the time when the paired-associate learning occurred was significant (F of 6.76 being required for significance at the 1 percent level of confidence.) This was similar to the results obtained with the previous measure of total errors. Excluding minor variations, this differential ease of learning in favor of the immediate paired-associate groups applied only to Conditions A and B. When the variance attributable to the time variable was tested for Conditions C and F, the two groups having physically similar syllables, an F ratio of less than one was obtained.

Although a ratio greater than one was obtained for the variance attributable to position effects, it was not significant at the .05 level of confidence. In the light of our hypothesis that the position effects, indicating the carry over of the inhibitory potential, would vary as a function of the experimental conditions, a non-significant F ratio would be anticipated for the total analysis in which the position effects for all six conditions were pooled. Substantiation of this interpretation is available from the significant variance attributable to the interaction of time and position (F ratio significant beyond the .05 level). This significant interaction indicates that there was a greater differential between the position means when the pairs were learned immediately following the serial learning than under the condition of delay.

In order to explore further the implications of the significant interaction of time and position, an analysis of variance was conducted for each condition individually. Position was the independent variable tested for each condition. Based upon 4 degrees of freedom, the position mean squares were compared with the within group variance for each condition. The relevant data of the six analyses are presented in Table XVII.

TABLE XVII

Ratios of Position Variance/Within Group Variance, Degrees of Freedom and F's for the Error Responses Obtained During First Four Trials for All Paired-Associate Conditions

Condition	Variance	df.	F	P
A - Immed. identical	2.29/.59	4/35	3.88**	.01
B - Immed. homophones	1.71/.49	4/35	3.49*	.05
C - Immed. phy. sim.	.66/.75	4/35	----	
D - Delay identical	.21/.59	4/35	----	
E - Delay homophones	.34/.27	4/35	1.26	
F - Delay phy. sim.	.84/.82	4/35	1.02	

Significant F ratios were obtained for the variances attributable to between position differences for Conditions A and B, both well beyond the .05 level of confidence. The null hypothesis applied to the position differences in these two conditions can not be accepted. The two bow-shaped curves of the position means expressed in terms of error responses obtained during the first two minutes of the paired-associate learning (Figure III) may, therefore, be considered as indicating significant trends. As we discussed earlier, the trends shown in the curves for Conditions A and B are in agreement with our prediction based on the transfer and generalization hypotheses of the inhibitory potential that was generated in the serial rote learning situation.

We have been able to confirm, to a large extent, the three hypotheses which defined the major problem under investigation in this study. We have shown through our complete analysis that (1) syllables learned near the middle positions of a serial learning list were more difficult to associate with other syllables in a subsequent paifed-associate learning situation, (2) this tendency of differential difficulty is more easily observable in the very brief span of time, approximately two minutes, immediately following the serial learning, and (3) that this difficulty occurred for syllables that were phonetically similar to the originally learned items as well as for those that were identical. We were unable to demonstrate the generalization of the inhibitory potential to syllables that were physically similar. This absence of evidence could have resulted from the *a priori* method used in selecting those syllables that were "physically similar" to the serial nonsense syllables.

Substantiation of this interpretation may be inferred from the previously discussed finding (on p. 54) that only with the groups using the physically similar syllables were the pairs easier to learn when the learning followed immediately after the serial learning than when the twenty-four hour delay intervened. This significant facilitation of the immediate learning was not obtained with either the identical or the phonetically similar syllables which by comparison demonstrated associative interference in accord with the assumed gradient of stimulus generalization.

An alternative explanation is that the absence of transfer to physically similar syllables was due to the chronological age of the subjects. That is to say that children in the age range used for this study are more sensitive to phonetical similarities than they are to physical similarities that must be visually perceived. Children's relatively greater sensitivity to homophones as against synonyms, in which similarity in meaning must be recognized, has been reported by Riess (24).

CHAPTER IV

SUMMARY AND CONCLUSIONS

Hull utilized the concept of an inhibitory potential in developing his theory of rote learning to account in part for the phenomenon of serial position effects. We presented a discussion of his theoretical formulation in Chapter I. This study has investigated whether or not the inhibitory potential developed in a rote serial learning situation would transfer to identical and similar items in a paired-associates learning situation.

Four hypothesis were presented and tested in this investigation. The experimental procedure used consisted of: (1) the learning of a serial list of eight nonsense syllables to a criterion of five correct anticipatory responses on any one trial, followed by (2) the learning of five pairs of nonsense syllables to full mastery in an adjusted learning situation. Two independent variables were studied in the second task: (1) the time interval between the two learning activities, and (2) the similarity between any one paired-associate stimulus member and its counterpart syllable in the initial serial list.

In formulating the basic problem of this study, the assumption was made that the bow-shaped curve of serial position indicates the presence of an inhibitory potential operating within the serial learning process. Although the curve of serial position had been reported as occurring under a great variety of conditions and with subjects of different ages, there had been no evidence that the phenomenon occurs with pre-adolescent subjects. Therefore the first hypothesis required the demonstration that the bow-shaped curve could be obtained with the sample used in this study.

Two measures of the serial learning process were applied, mean error responses for each position during all trials to criterion and mean error responses for each position on the criterion trial. The bow-shaped curve was obtained with both measures and found to be statistically significant at the 5% level of confidence. These results were interpreted as substantiating the first hypothesis and providing evidence of the presence of this aspect of learning behavior with pre-adolescent subjects.

The assumption had been made that the eight nonsense syllables of the serial list were of equal associative strengths but this was not indicated by the experimental results. The nonsense syllables were found to differ significantly from each other in terms of the total number of error responses associated with each syllable regardless of position in the serial list. These inter-syllable differences, however, were controlled adequately by the balancing procedure employed to overcome the inequalities of the syllables.

Whereas the results of the initial serial task provided the test of the first hypothesis, the remaining three hypotheses were tested by the paired-associates learning.

Two measures were used in analyzing the results of the paired-associate learning: (1) error responses occurring during the first four trials, and (2) error responses for all trials to criterion. The use of the former measure was based upon the assumption of rapid dissipation of the inhibitory potential, as postulated by Hull and his associates.

The second hypothesis predicted that the syllables learned in the middle positions of the serial list would be more difficult to associate with other new syllables than would those syllables that had occupied the end positions of the serial list. This statement provided an operationally feasable test of the general problem of transfer of the inhibitory potential.

The third hypothesis was specifically planned to test for the transfer in accord with the characteristics stipulated by Hull, i. e., the transfer should be most readily observed when the second learning immediately followed the serial learning. Actually the second and third hypotheses overlapped to the degree that experimental verification of the third hypothesis also tends to confirm the second hypothesis. Nevertheless, the second hypothesis could be accepted and the third hypothesis rejected.

The results of the two groups in which the original syllables were used as stimuli in the paired-associate learning apply to the second and third hypotheses. For the group having the paired-associates learning immediately following the serial learning, the pairs containing syllables which initially were learned in the middle positions of the serial list showed the greatest number of error responses. Graphically, the mean error responses of the respective pairs, when grouped according to the position occupied by the critical syllables in the serial list, presented the bow-shaped curve similar to that obtained from the serial learning. (Refer to Figure IV.) This relative differential inter-pair difficulty occurred with both measures; errors in first four trials and total trials to criterion. While the latter measure was not significant, the former measure was significant beyond the .05 level of confidence. For the group in which a twenty-four hour period intervened between the first and second learning stages no significant inter-pair differences were obtained. These results were interpreted as being in conformity with both the second and third hypotheses.

The fourth hypothesis investigated the extent of the generalization of the inhibitory potential to syllables that were either phonetically or physically similar to the syllables of the serial list. The results of four experimental groups directly pertain to this hypothesis. Inter-pair differential of learning difficulty, similar in form to the serial position curve, appeared only in the group that had learned phonetically similar syllables immediately following the serial learning and was observed only during the first four trials. This differential learning difficulty was statiscally significant. We may conclude that within the limits of this investigation we have demonstrated the predicted generalization of the inhibitory potential to syllables that were phonetically similar to the originally learned items.

Our inability to demonstrate the extent of the generalization of the inhibitory potential to syllables that were physically similar to the syllables of the serial list was viewed as resulting from the rather crude, formalistic method originally used in selecting the "physically similar" syllables. This conclusion infers that the syllables were, in reality, quite dissimilar from the serial items, at least for the subject sample of this investigation. Evidence supporting this interpretation is available from the results of this study. (Refer to page 54).

THEORETICAL IMPLICATIONS

We have demonstrated that the serial position effects generate in a conventional serial learning situation continue to act as inhibiting agents for a period of several minutes following the serial learning. Within this relatively brief period the inhibitory potential seems to act as a depressor of learning on those syllables with which it was initially associated even though those syllables are encountered in a new learning situation. This potential also generalizes to new syllables phonetically similar to the originally learned items.

Studies of the transfer of training or transfer effects are frequently classified as either <u>positive</u> or <u>negative.</u> We stated in our review of the literature that the terms <u>positive</u> or <u>negative</u> are applied in describing transfer effects depending upon whether or not previous learning served to improve or to retard the new learning. In the light of this differentiation, our results have indicated negative transfer effects. Yet, the actual carry over of the inhibitory potential from the first to the second learning may be considered as an example of what is frequently referred to as overt transfer which is always positive. Consequently, perhaps this investigation could be described as having demonstrated the positive transfer of an inhibitory potential with resultant negative transfer effects. However, in the present investigation of the transfer of a negative potential a rather unique type of transfer is involved. To that extent the above description does not appear to be sufficiently adequate or appropriate since the connotation of the terms implies the more "traditional" types of transfer studies. Although primarily a semantic problem, the possibility of our having demonstrated a "new" type of transfer is of considerable importance in the psychology of learning.

We have seen that the area of transfer of training occupies a venerable position in the study of learning processes. In the main, transfer of training research has been concerned with determining the skills, habits, processes and principles that are carried over from one learning situation to another, or in analyzing the two learning situations in terms of the stimulus and response factors involved. A relatively undeveloped area of investigation is that of the transfer of a negative potential. Some work had been done in regard to the transfer of fatigue. The present study has gone one step farther in investigating and demonstrating the transfer of an inhibitory potential that is developed during the serial learning process. We have provided substantial evidence in support of the concept of a negative potential capable of transfering to new learning situations and generalizing to similar items. The rather definitive results of this study should serve well in motivating further investigations of the transfer of this or other types of negative potentials.

Our findings are related to the work in semantic conditioning in which the generalization of a conditioned response to synonyms and homophones have been demonstrated. By using a different experimental method our results were found to be in conformity with the previous work done in this area. We do not claim the development of a more efficient methodology for the study of the generalization from one syllable to other syllables. We do believe that the technique described in this study may serve as an alternative and significant method for further investigations of verbal generalization.

In our discussion of the purpose and significance of this study emphasis was placed upon the possible implications that this study might have for two of the major theoretical interpretations of serial position effects. Hull interprets the phenomenon as being the manifestation of the assumed inhibitory potential, while Foucault's explanation involves the interaction of proactive and retroactive inhibition. This study was neither designed to serve as a critical test of either theory nor do our findings negate either of the two interpretations. On the contrary, the writer is confident that the proponents of either point of view could readily incorporate our findings into their respective theoretical formulations. The fact that the present study was planned within the framework of Hull's system of rote learning reflects the limited scope within which Foucault's explanation operates rather than questions the adequacy of his theory. In this respect our positive findings indicate the virtue of Hull's theoretical system in that it permits the unequivocal testing of deductions such as were made in hypothesis II, III, and IV.

Whereas the validation of the concepts of proactive and retroactive inhibition does not critically depend upon their appropriateness in explaining serial position effects, the concept of an inhibitory potential as developed by Hull rests heavily upon the intraserial phenomenon for support. The assumed inhibitory potential which occupies a vital position in Hull's rote learning theory was deduced primarily for his explanation of serial position effects. Consequently, an operationally definable demonstration of the effects of this potential, which we believe this study has shown, not only provides experimental evidence of the negative potential but also supports the relevant aspects of Hull's entire theory.

The assumption was made by Hull and his associates that the decay of the inhibitory potential is far more rapid than that of the excitatory potential. This assumption was necessary for their original prediction of serial position effects as well as for the reminiscence phenomenon. Our results are in close conformity with this assumed characteristic of the inhibitory potential.

Although the origin and nature of this inhibitory or negative potential could not be studied directly, our investigation has thrown more light on its nature and effects. It is the writer's opinion that the demonstration of the transfer of this potential to new learning situations and the generalization to similar items is a valuable contribution to the psychology of learning. It is quite probable that in many learning situations previously developed inhibitory potentials continue to operate to the degree of acting as determining factors in the nature and result of the learning. Although the inhibitory effects of this potential appear to be of a very brief temporal duration, they may operate to produce overall results that one could not predict or interpret without being aware of the presence of the inhibatory potential. In view of this implication, the use of procedures which control the transfer of negative potentials would be justified in any experiments on transfer of training, particularly if the initial task involved serial learning.

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APPENDIX

TABLE XVIII

Detailed Description of Subjects

Subjects		Sex	Age yrs.	Grade	I. Q.*	Readings**	S.L.#	P.A.##
1	C.B.	F	10.4	5A	131	5.9	I	A
2	S.G.	M	10.8	5A	119	6.0	I	B
3	R.G.	F	9.8	4A	115	5.4	I	C
4	D.L.	M	10.7	5A	116	7.8	I	D
5	G.C.	F	9.6	4A	121	5.4	I	E
6	C.S.	M	11.5	6A	124	8.3	I	F
7	J.K.	F	11.6	6A	130	8.8	II	A
8	B.S.	F	11.6	6A	122	6.2	II	B
9	S.L.	M	11.6	6A	120	7.6	II	C
10	L.R.	F	11.7	6A	132	9.3	II	D
11	R.D.	M	10.4	6B	115	6.2	II	E
12	L.L.	F	11.10	6A	114	8.5	II	F
13	J.S.	M	10.7	6A	132	9.0	III	A
14	S.S.	F	11.4	6A	117	7.4	III	B
15	L.W.	F	10.1	5B	118	5.8	III	C
16	R.F.	M	11.3	6A	132	10.9	III	D
17	R.P.	F	10.3	5B	119	6.2	III	E
18	L.S.	F	11.1	6A	119	9.5	III	F
19	V.L.	M	10.2	5A	114	6.4	IV	A
20	S.D.	M	10.0	5A	126	6.2	IV	B
21	S.F.	M	9.3	5B	135	7.4	IV	C
22	P.W.	F	9.11	5A	132	5.9	IV	D
23	B.V.	F	10.1	5B	130	6.6	IV	E
24	M.H.	M	11.5	6A	126	10.9	IV	F
25	E.S.	F	11.1	6A	115	7.8	V	A
26	R. S.	M	10.5	5A	127	8.5	V	B
27	N.F.	F	10.2	5A	123	8.1	V	C
28	L.T.	F	9.9	4A	112	5.4	V	D
29	E.F.	M	9.11	5A	132	5.9	V	E
30	J.F.	F	11.5	6A	120	10.0	V	F
31	J.B.	F	11.6	6A	120	8.1	VI	A
32	J.H.	F	11.2	6A	120	9.8	VI	B
33	R.D.	F	11.4	6A	119	10.3	VI	C
34	J.L.	M	10.8	5A	124	7.4	VI	D
35	J.C.	M	9.8	5B	115	9.8	VI	E
36	D.G.	M	11.4	5A	118	6.8	VI	F
37	M.B.	M	10.10	5A	114	6.6	VII	A
38	M.G.	M	9.9	4A	116	5.2	VII	B
39	N.G.	M	11.7	6A	118	9.8	VII	C
40	L.B.	M	9.5	4A	126	5.6	VII	D

TABLE XVIII a

Detailed Description of Subjects

Subjects	Sex	Age	Grade	I.Q.*	Reading**	S.L.#	P.A.##
41 R.W.	F	10.8	5A	122	7.4	VII	E
42 H.R.	F	9.10	5B	117	9.3	VII	F
43 A.S.	M	11.2	6A	128	9.0	VIII	A
44 M.K.	F	10.3	5A	130	10.0	VIII	B
45 F.G.	M	9.3	4A	126	5.1	VIII	C
46 H.C.	M	10.5	5A	114	8.5	VIII	D
47 J.L.	M	11.1	6A	124	7.2	VIII	E
48 I.F.	M	11.2	6A	117	7.2	VIII	F
Mean		10.6		122	7.6		
S.D.		2.75		6.3	1.8		

* Kuhlman-Anderson Group Measure of Intelligence

** Stanford Reading Achievement Test

\# Arrangement of syllables in the serial list as shown in Table V

\#\# Experimental groups in paired-associate learning as shown in Table VI

TABLE XIX

Total Errors for the Serial Learning for Each Subject and for Each Position

Order of presentation	Subjects	Position 1	2	3	4	5	6	7	8	Total Errors	Total trials
I	1	5	6	6	3	3	5	6	4	38	6
II	7	1	1	3	4	5	5	2	5	26	5
III	13	2	4	13	17	10	14	17	10	87	17
IV	19	7	8	3	6	5	9	7	6	51	9
V	25	9	9	9	7	7	7	7	7	62	9
VI	31	3	8	8	11	11	11	6	5	63	11
VII	37	3	1	10	7	10	10	3	7	51	10
VIII	43	3	7	3	8	8	6	5	5	45	8
	Sum	33	44	55	63	59	67	53	49	423	
I	2	7	9	9	10	9	3	9	7	63	11
II	8	6	15	12	14	12	15	13	11	98	15
III	14	1	3	3	8	9	10	10	9	53	10
IV	20	7	7	7	7	11	12	11	8	70	12
V	26	5	10	13	13	10	14	14	7	86	14
VI	32	4	13	15	11	18	11	17	13	102	18
VII	38	2	2	3	2	5	5	3	3	25	5
VIII	44	7	9	4	4	8	9	6	8	55	9
	Sum	39	68	66	69	82	79	83	66	552	
I	3	5	5	1	4	7	7	6	6	41	7
II	9	8	12	10	13	11	11	9	10	84	13
III	15	4	1	3	3	1	4	4	3	23	4
IV	21	7	7	9	11	7	9	7	6	63	11
V	27	3	6	4	10	10	11	11	7	62	11
VI	33	1	3	5	5	6	3	7	7	37	7
VII	39	5	3	6	4	8	8	7	6	47	8
VIII	45	5	6	6	5	6	4	4	6	42	7
	Sum	38	43	44	55	56	57	55	51	399	
I	4	6	10	9	10	7	5	8	5	60	10
II	10	4	7	7	9	8	7	3	5	50	9
III	16	4	4	5	2	4	6	7	3	35	8
IV	22	5	3	11	15	14	14	14	16	82	15
V	28	4	7	9	9	4	6	4	5	48	9
VI	34	5	1	11	15	11	14	16	11	84	16
VII	40	5	7	8	6	8	7	5	4	50	8
VIII	46	2	8	5	7	11	9	9	8	59	11
	Sum	35	47	65	73	67	68	66	47	468	

TABLE XIX a

Total Errors for the Serial Learning for Each Subject and for Each Position

Order of Presentation	Subjects	1	2	3	4	5	6	7	8	Total Errors	Total trials
I	5	9	11	9	8	11	9	11	9	77	12
II	11	4	4	5	5	7	7	6	5	43	7
III	17	6	8	12	9	13	14	11	2	75	14
IV	23	12	16	11	16	16	15	11	6	103	16
V	29	5	3	2	3	6	7	4	5	35	7
VI	35	2	2	7	5	8	8	7	7	46	8
VII	41	8	1	4	2	10	10	4	9	48	10
VIII	47	4	7	5	7	6	5	2	2	38	
	Sum	50	52	55	55	77	75	56	45	465	
I	6	5	4	4	4	6	4	6	4	37	6
II	12	3	6	5	4	6	4	3	3	34	6
III	18	3	2	6	6	5	6	4	2	34	6
IV	24	9	3	4	9	5	9	6	6	51	9
V	30	1	3	8	7	5	8	5	4	39	8
VI	36	3	6	11	10	13	9	12	9	73	13
VII	42	3	5	6	6	7	7	5	3	42	7
VIII	48	5	7	6	5	8	6	3	7	47	8
	Sum	32	36	50	51	55	51	44	38	357	
	Sum	227	290	335	366	396	397	357	296	2654	
	Mean	4.73	6.04	6.96	7.62	8.25	8.27	7.44	6.16	6.93	

TABLE XX

Error Responses for Each Order of Serial List Presentation*

Order	Position								Sum	Mean	
	1	2	3	4	5	6	7	8			
I	37	45	38	39	43	33	46	35	316	39.50	(4)
II	26	45	42	49	49	49	36	39	335	41.87	(6)
III	20	22	42	45	42	55	52	29	307	38.38	(3)
IV	47	44	45	64	58	68	56	38	420	52.50	(8)
V	27	38	45	49	42	50	46	35	332	41.50	(5)
VI	18	33	57	57	67	56	65	52	405	50.63	(7)
VII	26	19	37	27	48	47	27	32	263	32.87	(1)
VIII	26	44	29	36	47	39	29	36	286	35.75	(2)
Sum	227	290	335	366	396	397	357	296	2664	55.50	

* Each row based upon an N of eight subjects.

TABLE XXI

Error Responses of the First Four Trials for the Six Paired-Associate Learning Conditions

Cond.*	Syllable**	Positions Occupied by Identical or Similar Syllables in the Serial List					Sum
		2	3	5	6	8	
A	PEJ	2	4	4	2	2	14
	FEX	3	3	4	4	3	17
	COZ	2	3	3	4	2	14
	VOF	2	3	4	4	2	15
	TOJ	3	3	3	3	3	15
	BIK	1	2	4	4	3	14
	ZET	1	3	2	2	3	11
	MIB	3	4	4	3	4	18
	Sum	17	25	28	26	22	118
	Mean	2.12	3.12	3.50	3.25	2.75	14.75
B	DEJ	2	3	4	4	3	16
	FAX	3	4	4	4	4	19
	KOZ	3	4	4	4	4	19
	VOV	2	2	2	3	2	11
	TUJ	3	4	3	3	2	15
	BIQ	2	3	4	4	3	16
	ZED	4	4	4	4	3	19
	MIP	2	3	4	4	3	16
	Sum	21	27	29	30	24	131
	Mean	2.62	3.37	3.62	3.75	3.00	16.37
C	JEP	4	3	2	1	3	13
	PEM	2	3	4	4	3	16
	CAX	4	4	4	4	4	20
	VUP	4	3	4	3	2	16
	MOG	4	4	4	2	4	18
	KIB	4	4	3	3	4	18
	ZAL	2	4	2	2	3	13
	MIF	4	4	4	4	3	19
	Sum	28	29	27	23	26	133
	Mean	3.50	3.62	3.37	2.97	3.25	16.62

TABLE XXI a

Error Responses of the First Four Trials for the Six Paired-Associate Learning Conditions

Condition*	Syllables**		Positions Occupied by Identical or Similar Syllables in the Serial List					Sum
			2	3	5	6	8	
D	FEJ		2	4	4	4	1	15
	FEX		4	3	3	4	4	18
	COZ		3	4	4	4	4	19
	VOF		3	4	4	4	3	18
	TOJ		4	3	4	2	4	17
	BIK		4	4	4	4	4	20
	ZET		4	3	4	4	4	19
	MIB		4	4	4	2	4	18
		Sum	28	29	31	28	28	144
		Mean	3.50	3.62	3.87	3.50	3.50	18.00
E	DEJ		3	3	4	4	4	18
	FAX		4	3	4	4	3	13
	KOZ		4	3	4	4	4	19
	VOV		4	4	2	4	4	18
	TUJ		4	4	4	4	4	20
	BIQ		4	4	2	4	4	18
	ZED		4	4	4	4	4	20
	MIP		4	4	4	4	4	20
		Sum	31	29	28	32	31	151
		Mean	3.87	3.62	3.50	4.00	3.87	18.87
F	JEP		4	2	4	4	2	16
	PEM		4	4	4	2	2	16
	CAX		4	4	4	4	4	20
	VUP		4	4	4	3	3	18
	MOG		3	1	4	4	4	16
	KIB		4	4	3	3	4	18
	ZAL		4	1	2	4	4	15
	MIF		4	4	4	4	4	20
		Sum	31	24	29	28	27	139
		Mean	3.87	3.00	3.62	3.50	3.37	17.37
	Total	Sum	156	163	172	167	158	816
		Mean	3.25	3.39	3.58	3.48	3.29	17.00

* See Table VI for description of the six experimental groups.

** Syllables served as the stimulus member in the paired-associate learning.

TABLE XXII

Total Error Responses for All Learning Trials for the Six Paired-Associate Learning Conditions

Cond.*	Syllables**		Positions occupied by identical or similar syllables in the serial list					SUM
			2	3	5	6	8	
A	FEJ		2	11	4	2	3	22
	COZ		3	8	19	8	4	42
	FEX		16	5	6	9	4	40
	VOF		2	3	5	7	4	21
	TOJ		4	3	5	4	6	22
	BIK		1	3	5	29	4	42
	ZET		1	5	2	6	4	18
	MIB		4	4	5	10	25	48
		Sum	33	42	51	75	54	255
		Mean	4.12	5.25	6.37	9.37	6.75	31.87
B	DEJ		9	3	6	18	5	41
	FAX		13	9	11	11	14	58
	KOZ		13	4	8	12	10	47
	VOV		6	10	2	4	2	24
	TUJ		8	9	3	7	7	34
	BIQ		6	8	15	8	8	45
	ZED		7	13	5	4	3	32
	MIP		5	3	23	8	9	48
		Sum	67	59	73	72	58	329
		Mean	8.37	7.37	9.12	9.00	7.25	41.12
C	JEP		6	10	2	1	7	26
	FEM		2	4	8	5	4	23
	CAX		4	11	8	4	7	34
	VUP		8	7	9	4	3	31
	MOG		5	7	9	2	7	30
	KIB		5	12	3	6	8	34
	ZAL		2	6	2	2	5	17
	MIF		9	8	9	13	3	42
		Sum	41	65	50	37	44	237
		Mean	5.12	8.12	6.25	4.62	5.50	29.62

TABLE XXII a

Total Error Responses for All Learning Trials for the Six Paired-Associate Learning Conditions

Cond.*	Syllables**		Positions occupied by identical or similar syllables in the serial list					Sum
			2	3	5	6	8	
D	PEJ		2	13	8	14	1	38
	FEX		8	3	7	4	22	44
	COZ		3	7	17	5	4	36
	VOF		3	9	9	5	3	29
	TOJ		8	8	10	3	5	34
	BIK		12	14	26	9	11	72
	ZET		6	3	5	6	11	31
	MIB		9	34	6	15	12	76
		Sum	51	91	88	61	69	360
		Mean	6.37	11.37	11.00	7.62	8.62	45.00
E	DEJ		3	3	12	6	7	31
	FAX		11	3	6	12	3	35
	KOZ		10	3	10	8	6	37
	VOV		4	8	2	4	4	22
	TUJ		19	10	9	11	6	55
	BIQ		11	9	2	15	4	41
	ZED		4	11	6	6	17	44
	MIP		7	4	14	13	18	56
		Sum	69	51	61	75	65	321
		Mean	8.62	6.37	7.62	9.37	8.12	40.12
F	JEP		10	2	10	10	2	34
	PEM		11	17	4	3	2	37
	CAX		6	9	15	4	5	39
	VUP		9	13	8	5	3	38
	MOG		16	1	4	5	14	40
	KIB		15	13	16	8	13	65
	ZAL		15	1	6	6	13	41
	MIF		8	12	4	13	12	49
		Sum	90	68	67	54	64	343
		Mean	11.25	8.50	8.37	6.75	8.00	42.87
	Total	Sum	351	376	390	374	354	1845
		Mean	7.37	7.84	8.12	7.79	7.38	38.44

TABLE XXIII

Error Responses During the First Four Trials for Condition A and D of the Paired-Associate Learning

Time	Position in serial list					Sum
	2	3	5	6	8	
Immediate	17	25	28	26	22	118
24 hour delay	28	29	31	28	28	144
Sum	45	54	59	54	50	262

TABLE XXIV

Analysis of Variance of Error Responses During First Four Trials for Condition A and D of the Paired-Associate Learning

Source of variation	df.	Sum of squares	Mean square	F	F (.05)	F (.01)
Position	4	6.82	1.71	2.90*	2.50	3.60
Time	1	8.45	8.45	14.32**	3.98	7.01
Pos. x Time	4	3.18	.80	1.36	2.50	3.60
Error	70	41.50	.59			
Total	79	59.95				

TABLE XXV

Error Responses for the First Four Trials for Condition A and B of the Paired-Associate Learning

Form	Position in serial list					Sum
	2	3	5	6	8	
Identical	17	25	28	26	22	118
Homophones	21	27	29	30	24	131
Sum	38	52	57	56	46	249

TABLE XXVI

Analysis of Variance of Error Responses During First Four Trials Under Condition A and B of the Paired-Associate Learning

Source of variation	df.	Sum of squares	Mean square	F	F (.05)	F (.01)
Position	4	15.99	4.00	7.84**	2.50	3.60
Form	1	2.11	2.11	4.14*	3.98	7.01
Residual (Error)	74	37.88	.51			
Total	79	55.98				

TABLE XXVII

Analysis of Variance of Error Responses During First Four Trials of the Paired-Associates Learning for Conditions B and E

Source of variation	df.	Sum of squares	Mean Square	F	F (.05)	F (.01)
Position	4	3.32	.83	2.18	2.50	
Time	1	5.00	5.00	13.16**		7.01
Position X Time	4	4.87	1.22	3.21*	2.50	
Within (Error)	70	26.75	.38			
Total	79	39.94				

TABLE XXVIII

Analysis of Variance of Error Responses During First Four Trials of the Paired-Associate Learning for Conditions C and F

Sourse of variation	df.	Sum of squares	Mean square	F	F (.05)	F (.01)
Position	4	2.45	.61	----		
Time	1	.45	.45	----		
Pos. X Time	4	3.55	.89	1.14	2.50	
Within (Error)	70	54.75				
Total	79	61.20				

TABLE XXIX

Error Responses for the First Four Trials for All Conditions of the Paired-Associate Learning with Position and Time as the Independent Variables

Time	Position in serial list					Sum
	2	3	5	6	8	
Immediate	66	81	84	79	72	382
24 hour delay	90	82	88	88	86	434
Sum	156	163	172	167	158	816

TABLE XXX

Error Responses for the First Four Trials for All Conditions of the Paired-Associate Learning with Position and Form as the Independent Variables

Form	Position in serial list					Sum
	2	3	5	6	8	
Identical	45	54	59	54	50	262
Homophones	52	56	57	62	55	282
Physically similar	59	53	56	51	53	272
Sum	156	163	172	167	158	816

TABLE XXXI

Error Responses for the First Four Trials for all Conditions of the Paired-Associate Learning with Time and Form as Independent Variables

Time	Form			Sum
	Iden.	Homo.	Phy. Similar	
Immediate	118	131	133	382
24 hour delay	144	151	139	434
Sum	262	282	272	816

TABLE XXXII

Analysis of Variance of Error Responses During First Four Trials Under Condition A, B, D, and E, of the Paired-Associate Learning

Source of variation	df.	Sum of squares	Mean square	F	F (.05)	F (.01)
Position	4	8.09	2.0	4.12**	2.43	3.44
Time	1	13.22	13.22	26.98**	3.91	6.81
Form	1	2.50	2.50	5.10*	3.91	6.81
Position X Time	4	7.59	1.90	3.88**	2.43	3.44
Position X Form	4	2.06	.51	1.04	2.43	3.44
Time X Form	1	.23	.23	----		
Pos. X Time X Form	4	.46	.11	----		
Error	140	68.25	.49			
Total	159	102.40				

TABLE XXXIII

Analysis of Variance of Error Responses During First Four Trials of the Paired-Associates Learning for Conditions B and C

Source of variation	df.	Sum of squares	Mean square	F	F (.05)	F (.01)
Position	4	23.92	5.98	----		
Form	1	105.80	105.80	6.95*	3.98	7.01
Position X Form	4	60.47	15.12	----		
Within (Error)	70	1065.35	15.22			
Total	79	1255.54				