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APPLICATION OF BOWER'S ASSOCIATION MODEL TO PAIRED-ASSOCIATE TRANSFER

By

Edward J. Rickert

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Arts in Psychology

The University of New Mexico

1963

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

W. J. Parish
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MASTER OF ARTS

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INTRODUCTION TO THE PROBLEM

The purpose of this experiment was to examine the predictive power of Bower's associative model in an investigation of the "hook-up" phase of paired-associate transfer. Presumably, if the model had sufficient power to generate results predicting transfer performance, then other aspects of the verbal learning process, e.g., the response-learning stage, might conceivably submit to a similar analysis. Thus, a synthesis of the laws governing verbal learning could possibly be achieved via mathematical integration.

An empirical analysis was also performed on the data. This analysis enabled E to determine the effect of stimulus similarity on a variety of dependent variables when the response-learning stage was virtually eliminated.

Studies of acquisition and transfer phenomenon (Underwood, Runquist, and Schulz, 1959; Underwood and Schulz, 1960a; Underwood and Schulz 1960b; Ellis and Burnstein, 1960) suggest that a paired-associate task may be logically analyzed into two stages--the response-learning stage and the associative or "hook-up" stage. During the first phase, S must learn to recall the response or to bring the response to a high degree of availability. If the response is not a part of S's repertoire (e.g., a nonsense syllable such as NUR), S must learn to integrate the various components of

the response. The second stage, although logically but not necessarily temporally distinct, describes that phase of the verbal learning process in which the S forms an association of the response member to its appropriate stimulus.

The advantage of this logical distinction between the two stages of verbal learning is that this division serves as an analytical device which permits an investigation of the associative phase independent of the other. An examination of the response-learning stage as distinct from the "hook-up" phase is not readily apparent, however. The difficulties have been succinctly summarized by Underwood and Schulz:

> First, for some items in a list, both stages may be virtually complete before the first stage is complete for other items. Secondly, for some items the second stage may overlap the first in the sense that some degree of association may develop between the stimulus and response (second phase) while response integration is taking place.... Finally, the specific stimulus to which a response is to be associated may have associative strength to this response before the list is actually presented to the subject. In this case, response learning is circumvented since the stimulus is the immediate eliciting agent. (p. 93, 1960)

The difficulties enumerated by Underwood and Schulz can be overcome in an investigation of the associative stage, i.e., the "hook-up" phase can be studied relatively independent of the response-learning stage, provided that the response items selected (a) do not require integration and hence are recallable as units and (b) have a high probability of emission. This condition can be met by selecting items which have a high frequency of occurrence and which are made available to the subject prior to the learning task. Even granting conditions (a) and (b), a difficulty still remains;

viz., the number of responses (N) available to the S appears to affect the effectiveness of a reinforced trial on performance. Riley (1952) investigated the relationship between distribution of practice and the number of possible alternative responses which may be made to each stimulus. His results show that the number of errors Ss make before reaching one perfect recitation is greater the larger the number of response alternatives. In a series of experiments Noble (1955, 1957) required Ss to learn an invariant sequence of four pushbutton responses on a Selective Mathometer under varying conditions of response availability. It was observed that N exerted a retarding effect upon the rate of trial-and-error learning. Neither the Riley nor the Noble experiments, however, offer any clear-cut solution as to whether N alters the guessing behavior of S or affects the learning rate of a task. Indeed, no operational criteria exist to determine whether an item has been conditioned or guessed correctly when N is employed as an independent variable.

This situation is one in which a theoretical model of learning can make a definite contribution. For, with a set of rational equations which assumes the rate parameter to be constant for all groups, one can postulate *a priori* that N affects only the guessing behavior of Ss and not their learning rate. By varying N in a paired-associate task, Bower (1962) found that differences in performance were accounted for in a model which assumed that the learning process underlying each task was the same, whereas N

influenced only the probability of a correct guess. The experiment showed that the rate (c) at which a task was learned and N for a given task were both necessary and sufficient conditions for an explanation of the "hook-up" stage of acquisition. Bower's model assumes that the stimulus element is either conditioned or unconditioned to the correct response, and that on each reinforced trial the probability of a transition from an unconditioned to a conditioned stage is a constant c. The learning rate (c), then, represents the probability that an unconditioned stimulus item becomes associated to its corresponding response member as the result of a single reinforced trial. The probability that an item remains unconditioned is 1 - c. The probability that a response member fails to become conditioned after n reinforced trials is $(1 - c)^n$.

Even though N does not appear to affect the learning rate constant, its effect on the subject's guessing behavior must be taken into account. Bower states that, if the stimulus element is in an unconditioned state, then the probability of a correct response is $\frac{1}{N}$. In order for $\frac{1}{N}$ to express truly the probability of a correct guess, the model assumes that all response members are equiprobable and that each subject is instructed to respond on each trial regardless of his correctness. Given these assumptions, the probability of an incorrect guess is $1 - \frac{1}{N}$.

Proceeding with the above assumptions, the probability that a subject responds incorrectly to a given item on the nth

trial is designated as q_n. The value of q_n may be determined by noting that the probability that the item has failed to be conditioned during the preceding n - 1 trials is $(1 - c)^{n-1}$; and if the item is not conditioned, then the probability of guessing incorrectly is $1 - \frac{1}{N}$. Hence, the probability of an error on Trial n is given by the product of these two factors:

$$q_n = (1 - \tfrac{1}{N})(1 - c)^{n-1}. \quad [1]$$

As a result of the predictive success of the model in several studies in the acquisition of paired-associates (Bower 1961, 1962), it is proposed that the axioms of the model by extended into an investigation of the associative stage of transfer. In order to arrive at a set of rigorous predictions, regarding the hook-up phase of a transfer task, several assumptions appear to be necessary. The first assumption is that the processes underlying the "hook-up" phase of a transfer task are equivalent to the same stage during acquisition. Since c expresses the learning process, the probability of a transition from an unconditioned state to a conditioned state should remain invariant; that is, the learning rate (c) of the transfer group should be identical to that of the control.

Secondly, it is assumed that, if the stimulus items on the transfer task are sufficiently similar to those of the original task, then on Trial 1 of the transfer task a certain proportion of items will already be conditioned; other items, however, will not possess sufficiently similar properties to the original stimuli and will fail to generalize. No change

should be observed in N, since the number of responses available to the subjects will remain the same for both tasks.

It might be argued that the assumptions stated above are not necessarily related to the theoretical model. And, although it is true that no necessary relationship exists between the theory and the assumptions (for the assumptions could have been made even if the theory did not exist), a sufficient condition does exist. Moreover, the purpose of this paper is to test the power of a theory, i.e., to determine if the theory is capable of generating results that relate to a wide range and an apparent diversity of phenomena. The rationale of this approach has received its most concise formulation from Estes:

> Those not actively involved with the development of mathematical learning theory have been known to admit curiosity as to why it should be considered an important accomplishment when a mathematical model is found to reproduce accurately the data of a learning experiment, especially when the model is palpably too simplified to represent more than some very limited aspect of the organism's behavior. The reasons for questions of this kind may be found in the peculiar tradition of theory in psychology . . . . A type of theory which has evidently played fully as important a role in other sciences as the evolutionary and the reductionistic is that which seeks interpretations of phenomena, not in terms of more molecular underlying events, but in terms of "rules of operation."
>
> The standard procedure in physical theories of this sort [those involving "rules of operation"] has been, first, to develop quantitative descriptions of empirically determined relationships among observables as, for example, Kepler's Laws; then to seek simpler, usually more abstract, descriptions of the changes in behavior of the system in question at a particular instant, expressed as a function of momentarily effective variables; and finally to derive from these latter, via mathematical integration over time, the macroscopic laws of behavior. (p. 113, 1962)

In order to determine whether the learning rate (c) is constant for both the control and transfer groups, the value of q_1, the probability of an error on Trial 1 of the transfer task must be determined. Assuming that previous experience on the training task will increase the probability of a correct association for some items on Trial 1 of the transfer task and that the learning rate will remain constant, the value of q_1 should correspond to a value of q_n which would be obtained from some trial during the learning of the original list. Stated differently, if the learning rate (c) for the control and transfer groups remains invariant, then the slope constant for both groups should be identical. But if a certain proportion of items is conditioned on the first trial of the transfer task, the intercepts of the two curves should be quite distinct, with the intercept of the transfer curve corresponding to a point expressed by q_n on some trial, i.e., Trial n. Figure 1 depicts the hypothetical relationship which should be obtained if the preceding assumptions hold.

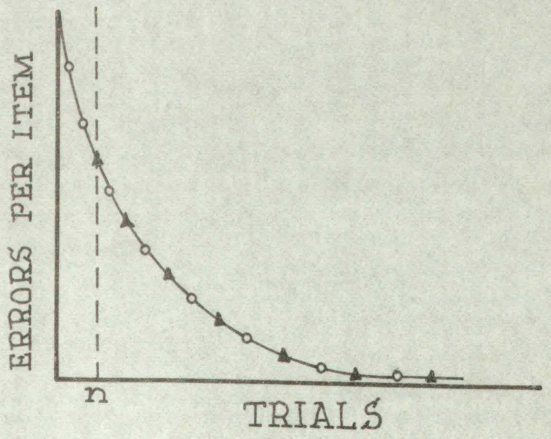


Figure 1. The hypothetical relationship predicted for the control and transfer groups.

The curve in Figure 1 shows the expected probability of an error per item for the control group. The vertical dotted line depicts the ordinate for the transfer group. The intersection of the transfer group's ordinate with the learning curve for the control group represents that trial during initial learning which corresponds to Trial 1 of the transfer task. The open dots on the curve represent the expected values for the control group; the triangles represent the predicted values for the transfer group.

The procedure employed to ascertain the value of q_1 for the transfer group is as follows:

Since Equation 1 expresses the probability of an error on Trial n, the summation of the equation from the first trial to an infinite number of such trials $\left(\sum_{n=1}^{\infty} q_n \right)$ represents the expected total number of errors per item before perfect learning. In order to estimate the total number of errors per item for the transfer task, the limit of $\sum_{n=1}^{\infty} q_n$ must be determined for the control group. Employing the formula for an infinite geometric series, the equation for the expected total number of errors per item prior to perfect learning is

$$\sum_{n=1}^{\infty} q_n = u_c = \frac{1 - \frac{1}{N}}{c} \qquad [2]$$

where u_c is the expected total number of errors per item. The derivation for Equation 2 is presented in Appendix A.

Given the assumption that the slope constant for the control and transfer groups will remain unchanged, but that

the intercept of the transfer group on the first trial of the transfer task will correspond to some trial of the control group, the expected total number of errors per item for the transfer task, designated as u_t, may be obtained by the following:

$$u_t = \sum_{n=K}^{\infty} q_n = \sum_{n=1}^{\infty} q_n - \sum_{n=1}^{K} q_n \qquad [3]$$

where $\sum_{n=K}^{\infty} q_n$ expresses the expected probability of an error on the kth trial to an infinite number of trials for the control group, $\sum_{n=1}^{\infty} q_n$ equals the estimated total number of errors from the first trial to an infinite number of such trials, and $\sum_{n=1}^{K} q_n$ equals the expected total number of errors per item from Trial 1 to Trial k for the control group.

Substituting terms for Equation 1 and 2 into Equation 3, the expression now becomes

$$u_t = u_c - (1 - \tfrac{1}{N}) \sum_{n=1}^{k} (1 - c)^{n-1} \qquad [4]$$

Employing the formula which determines the sum Sn of a finite number of terms for a geometric series

$$S_n = \frac{a(1 - r^n)}{1 - r}$$

and setting (1 - c) equal to r, Equation 4 becomes

$$u_t = u_c - (1 - \tfrac{1}{N}) \left[\frac{1 - (1 - c)^{n-1}}{1 - (1 - c)}\right]$$

Simplifying,

$$u_t = u_c - (1 - \tfrac{1}{N}) \left[\frac{1 - (1 - c)^{n-1}}{c}\right]$$

or,

$$u_t = u_c - \frac{(1 - \frac{1}{N}) \left[1 - (1 - c)^{n-1}\right]}{c}$$

and, since $u_c = \frac{1 - \frac{1}{N}}{c}$, u_c may be factored in the right member of the equation giving,

$$u_t = u_c \left\{1 - \left[1 - (1 - c)^{n-1}\right]\right\}.$$

Simplifying,

$$u_t = u_c (1 - c)^{n-1}. \qquad [5]$$

Equation 5 represents the estimated total number of errors per item before perfect learning on the transfer task. In order to determine q_1 for the transfer group, i.e., to obtain the expected probability of an error on Trial 1 of the transfer task, it is necessary to solve for the exponent n.

Dividing both sides of equation 5 by u_c, the following equation is obtained:

$$\frac{u_t}{u_c} = (1 - c)^{n-1}. \qquad [6]$$

By taking logarithms of both sides of the equation, we obtain

$$(n - 1) \log (1 - c) = \log \frac{u_t}{u_c}$$

or,

$$n = \frac{\log \frac{u_t}{u_c}}{\log (1 - c)} + 1 \qquad [7]$$

where n represents the trial during initial learning which should correspond to Trial 1 of the transfer task, u_t is the expected total number of errors per item prior to complete

mastery for the transfer group, and u_c stands for numbers of estimated errors per item before perfect learning for the control group. (1 - c) is a constant which expresses the probability that the item remains unconditioned.

In summary, the purpose of this experiment is to test the generality of Bower's model, i.e., extend the theory over a wider range of phenomena. Since, however, the available data will permit a more extensive examination, five other criterion measures will be analyzed in order to assess the effect of stimulus similarity on the association stage of a paired-associate transfer task. These are (a) mean number of correct responses on the first trial of the transfer task, (b) trials to criterion, (c) errors, (d) empirical intercept constants for the control and transfer groups, and (e) empirical slope constants for the control and transfer groups. The purpose of the empirical analysis is (1) to affect a comparison with several transfer studies (Ellis, 1958, 1960) that have employed different criterion measures to determine the effect of stimulus similarity on transfer of training and (2) to determine if a different paradigm and/or instructional procedure produces differences over and above the effects of the experimentally controlled parameters.

EXPERIMENTAL DESIGN

General Nature of the Design. Traditionally with studies investigating the effect of a preceding activity upon the learning of a new task, all Ss in the experimental groups learned an identical first list of stimulus-response pairs, and then were presented a second list in which either the stimulus or response members were varied. In order to assess the weight of the independent variable, each experimental group required a corresponding control which served as a base-line. Differences between scores, e.g., errors, trials to criterion, etc., of the experimental and control groups on the transfer task would then be interpreted as evidence for the interfering or facilitative effects of the designated experimental activity. A typical transfer paradigm is shown in Table 1. The notation system in the table is identical to that employed by Osgood (1953).

TABLE 1

Typical Transfer Paradigm Employing Osgood's Notation

Group	First-List Learned	Second-List Learned
Experimental	$S_o - R_o$	$S_x - R_o$
Control	———	$S_x - R_o$

The subscripts for the first-list of S_o - R_o pairs represent the original stimulus and response members whereas the subscript for the stimulus item on the second-list expresses a variation in the similarity of the stimulus to its original member. The particular advantage of Osgood's notational procedure is that it enables E to express the degree of the stimulus and response similarity to the original S-R pairs. In interpreting results obtained with the paradigm depicted in Table 1, the assumption is made that "the pretest behavior of the control Ss is identical to that in which the experimental Ss would have indulged had they not been learning the original task." (Osgood, p. 521, 1953)

In order to test whether c of the transfer group is identical to that of the control, a design must be selected which would enable the E to achieve control over possible interlist differences on the transfer task. The control is crucial for c might be different if different transfer lists were used. The paradigm represented in Table 2 mitigates the effect of interlist differences on c since both the stimulus and response items learned on the second-list are identical for all groups.

TABLE 2

Basic Transfer Paradigm Employed to Test Bower's Association Model in a Paired-Associate Transfer Task

	First-List Learned	Second-List Learned
Experimental Groups	$S_M - R_o$	$S_o - R_o$
	$S_L - R_o$	$S_o - R_o$
Control Group	———	$S_o - R_o$

With the transfer model shown in Table 2, the two experimental groups learn different initial lists and all groups (both experimental and control) learn an identical second-list. The present paradigm then is simply the mirror-image of the typical transfer model presented in Table 1, with the exception that the design in Table 2 obviates the need for a separate control group for each experimental group.

The first list which is learned by the experimental group $S_M - R_o$ differs from its second list in that the stimuli presented on the initial task (S_M) are only moderately similar to those learned during the transfer (S_o). The second experimental group's ($S_L - R_o$) initial list of S-R pairs differs from the second-list in that the stimulus items of the initial list (S_L) are low in similarity to the

transfer list (S_0). The transfer lists of the two experimental groups are identical to the list learned by the control group. The S-R pairs used in the second-list are presented in Appendix B.

SUBJECTS Forty-two undergraduates from the University of New Mexico, all of whom were naive to verbal learning experiments, were used for the present experiment. Twenty-eight subjects were assigned randomly to the two experimental conditions (14 subjects/group), and 14 subjects were assigned to the single control group.

APPARATUS The apparatus used in the experiment was two Missouri-type memory drums.

MATERIALS The learning materials consisted of two training lists and one transfer list of eight paired-associates each. The stimulus items for the initial lists were selected from Haagen's (1949) list of adjectives scaled for meaningful similarity. Haagen scaled 400 pairs of common two-syllable adjectives for the degree of synonymity. The adjectives were incorporated into 80 sets of six words each. Judges selected from each set the word most representative of the set. The remaining five words were then compared to the standard or anchor word on a seven-point scale of meaningful similarity. Ellis (1958) employed an identical method with a sample of 60 word-pairs in order to estimate the reliability of Haagen's scale values. The only difference in procedure between the Haagen and Ellis experiments was that Ellis

presented the word-pairs in a mimeographed booklet whereas Haagen presented the word-pairs tachistoscopically. The mean scale values for the stimulus items of moderate and low similarity are those obtained from the Haagen experiment. The adjectives used with the first experimental group (S_M -R_o) on the initial task were moderately similar to the original stimulus items (S_o - R_o) having a mean scale value of 2.6. The second experimental group (S_L - R_o) was presented with adjectives of low similarity to those on the transfer task (S_o - R_o) having a mean scale value of 4.2. The adjectives selected were employed in a previous experiment by Ellis (1958).

Although Bower (1961, 1962) used nonsense syllables with low association values (5%), the use of nonsense materials here seemed unwise because the substitution of a letter or letters of the nonsense syllables would have increased intralist similarity in the transfer list and altered the association values of the syllables themselves.

The response members for all lists consist of the integers 1 through 4. Each response, then, will be paired with two stimuli within each list. Since Bower's model assumes that the probability of the Ss guessing behavior remains constant, pairing a different response to each stimulus could conceivably alter the guessing probabilities of the subject; that is, S, after hooking up a response to its appropriate stimulus, might eliminate that response from further consideration and thereby decrease the probability of

an incorrect guess.

The response members were assigned randomly to each stimulus in the second-list. The response members which had previously been paired with the original stimulus items (S_o) in the second list then were paired with the appropriate stimulus in the initial lists. For example, if the response "1" was paired with the stimulus "agile" in the second list, that same response member was paired with "lively," the stimulus of moderate similarity which corresponded to the original stimulus. The same condition applies to the stimulus items of low similarity--the response "1" was paired to the stimulus "tripping."

PROCEDURE The two experimental groups learned two distinct lists of eight adjectives (which differed in scaled similarity) and the integers 1, 2, 3, and 4. The material was presented on a Missouri-type memory drum at a three-second rate using the anticipation method; the interval between lists was also three seconds. Three orders of presentation were used in order to minimize serial effects. The criterion of learning was two successive errorless runs through the entire list.

After completion of the first list and five-minute rest period, the experimental Ss were required to learn the second-list of adjectives and the first four integers. The second list for the experimental and control group was identical. The same conditions and criterion of learning were used in the transfer task as in the initial situation.

INSTRUCTIONS TO Ss The instructions to Ss were adapted from material similar to that given by Ellis and Burnstein (1960), with the exception that Ss were requested to respond to each stimulus by a guess if the correct response had not been learned.

> This is an experiment in verbal learning. Your task will be to learn to associate a list of adjectives with a list of numbers. At first, when I start this device, you will see an adjective which we shall call a stimulus exposed in the window. It will appear for three seconds and then it will disappear. Then, you will see the same adjective again, but this time it will be paired with a number; this pair will be exposed for three seconds. Your task will be to associate this adjective with its response mate in such a way that at some later time in the experiment when you are shown the adjective alone, you will be able to produce the correct response. One thing more--the responses with which you must respond are the numbers 1, 2, 3, 4. During the exposure of the stimulus item you must guess which response it is paired with. It is extremely important to guess for each stimulus item even if you do not know the correct response. Remember, the responses are 1, 2, 3, or 4. The list is presented in several orders, so don't try to learn the position of the stimulus or response. Once the experiment starts, it goes continuously until you have completely learned the list. Are there any questions?

If the S is a member of either experimental group, he is instructed to learn the second-list in a manner identical to that of the first-list.

RESULTS AND DISCUSSION

This chapter consists of a joint presentation of the results of the experiment and a discussion of these results. Although this approach departs from the conventional procedure of presenting these chapters separately, the theoretical nature of the data warrants such a presentation. The chapter is subdivided, however, into two sections. The first topic under examination is the theoretical analysis of the data which pertains directly to the generality of the model and to the quantitative hypothesis concerning the transfer process. The empirical analysis of the data appears in the second section. The empirical analysis assesses the role of stimulus similarity on the associative stage of verbal transfer.

Theoretical Analysis of the Data

Analysis of the Control Group Data. Before an analysis of the transfer data could be undertaken, it was first necessary to determine the goodness of fit between the observed and predicted values of the control group, for, if the theory failed to hold for the acquisition data, further analysis would have been superfluous as well as impossible.

The basic learning parameter, c, had to be estimated before the model could be evaluated. The reduction process (Lewis, 1960) was employed to secure a least squares estimate

of c. This method has been characterized as involving " . . . successive trial-and-error manipulations of the data until a linear relationship is obtained between some function of the independent variable and some function of the dependent variable." (Lewis, p. 51, 1960).

The line of best fit was obtained by a logarithmic curve of the general form

$$Y = a \log X + b \quad [8]$$

This equation indicates that Y is a linear function of log X. The experimental data obtained from the control group revealed that the sum of the squares of the residuals was a minimum when proportion of correct responses was plotted against log trials.

A logarithmic curve of the form

$$Y = .515 \log X + .250$$

was generated. The slope of the reduction line (where a = c) yielded a value of .515, and the intercept of the line (where $b = 1 - \frac{1}{N}$) yielded a value of .250. Thus, the slope constant obtained by fitting the learning curve (i.e., proportion of correct response vs. trials) for this group was c = .515.

An indication of the correspondence between theory and data is seen in Figure 2. The figure represents the predicted and observed values for the average number of errors per item as a function of trials. The only divergence between theory and data occurred between trials five and eight.

This result is somewhat surprising. Since only four

responses were available for the eight stimulus items, and since each response was paired with two items, Ss may have eliminated a response member from consideration after pairing that response to its appropriate stimuli. This effect would have decreased the probability of an incorrect guess and presumably decreased the observed values rather than increased them.

Nevertheless, the goodness of fit between the theoretical and observed values is more than sufficient to warrant that the model was adequate for an examination of the transfer data. An additional illustration that the model is an adequate one is demonstrated in Table 3. The table represents the average total errors per item prior to perfect mastery. The prediction for the control group was obtained by solving Equation 2. The observed means were obtained by summing the average number of errors per item across trials. Inspection of the predicted and observed means for the control group indicates that the theory performed adequately in predicting the average total errors. Discussion of the predicted and observed values for the experimental groups will be deferred until an explanation is given for the derivation of their predicted mean values.

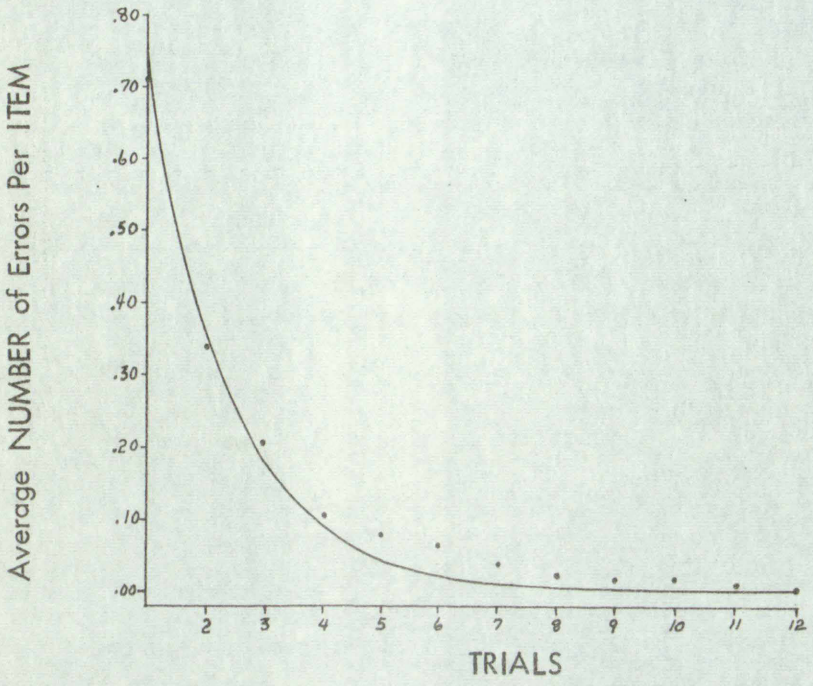


Figure 2. Average number of errors per item plotted as a function of trials for the S_O group. (The smooth curve represents predicted values; the dots near the curve represent the corresponding observed values.)

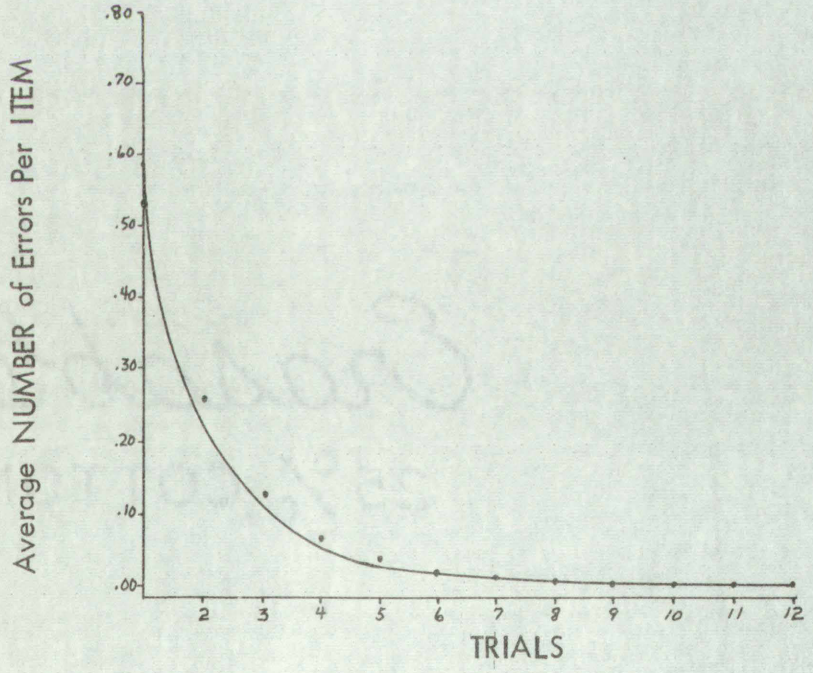


Figure 3. Average number of errors per item plotted as a function of trials for the S_M group. (The smooth curve represents predicted values; the dots near the curve represent the corresponding observed values.)

Figure 2. Average number of errors per item as a function of trials for the S^O group. (The smooth curve represents predicted values. The dotted curve represent the corresponding observed values.)

Figure 3. Average number of errors per item as a function of trials for the S^M group. (The smooth curve represents predicted values. The dotted curve represent the corresponding observed values.)

TABLE 3

AVERAGE TOTAL NUMBER OF ERRORS PER ITEM

OBSERVED AND PREDICTED

	Transfer Task	Predicted M	Observed M
Experimental Groups	S_L	1.04	1.03
	S_M	1.16	1.15
Control	S_0	1.46	1.67

Analysis of the Transfer Data. Before Equation 7 could be solved, it was necessary to obtain the observed total number of errors per item (U_T) for the S_M and S_L groups. The observed means were obtained by summing the average number of errors per item across trials for S_M and S_L, respectively. A comparison of the total number of errors per item both predicted and observed for the S_L and S_M groups is presented in Table 3. The predicted and observed means are almost identical. The data indicated, then, an almost perfect degree of correspondence between theory and data on the paired-associate transfer task. (Predicted and observed average number of errors per item for each trial for the three groups is presented in Appendix D.) The obtained U_T values were then employed in Equation 7 in order to derive the trial number of the S_0 group which would correspond to Trial 1 of the transfer task for both experimental groups.

When the observed mean of the S_L was used in Equation 7,

that trial number of the S_O group which matched Trial 1 of the S_L group on the transfer task was 1.33. The trial number of the S_O group which corresponded to Trial 1 of the S_M group on its transfer task was 1.47. Predicted average number of errors per item was calculated for the S_L and S_M groups by substituting that group's corresponding n value in Equation 1. The degree of correspondence between predicted and observed values in striking.

An indication of the goodness of fit of the theory is shown graphically in Figures 3 and 4. Figure 3 represents the predicted and observed values for the S_M group. The smooth curve represents the theoretical values and the dots near the curve the corresponding empirical values. A comparison of the intercepts of the S_O and S_M groups reveals a considerable decrease in the S_M group's intercept constant. The theoretical and empirical values for the S_L group can be seen in Figure 4. Of special significance is the fact that the intercept constant for the S_L group falls approximately half-way between the intercepts of the S_O and S_M group.

This finding lends additional support to the assumption that the number of correct associations made on the first trial of the transfer task is contingent upon the degree of stimulus similarity between the first and second task. Since the stimulus items of the S_M group when contrasted with that of the S_L group possessed a greater degree of similarity to the control group, a corollary of the assumption would predict that a larger proportion of items would be conditioned

for the S_M group. Stated differently, the S_M group's intercept constant on Trial 1 of the transfer task would have a lower value than either the control or low similarity groups. The intercept constant for the S_L group should fall between the value of S_M and S_0 on the first trial of the second list. Thus the results pictured graphically in Figures 3 and 4 confirm both the assumption and its corollary.

Table 4 presents the empirical and theoretical intercept constants which were obtained for the three groups. Intra-group comparison of the intercepts shows that little difference exists between predicted and calculated values for each group. Inter-group comparison indicates an exact isomorphism between the theory and data. The finding indicates that the shift on the curve, i.e., the change in the intercept constant, is proportional to the number of stimulus elements that the initial and transfer tasks have in common. The amount of transfer obtained, then, was a function of the identity of elements between the tasks.

TABLE 4

THEORETICAL AND EMPIRICAL INTERCEPT CONSTANTS WHEN AVERAGE NUMBER OF ERRORS PER ITEM IS PLOTTED AGAINST TRIALS

		Predicted	Observed
Experimental Groups	S_L	.59	.63
	S_M	.53	.59
Control	S_0	.75	.71

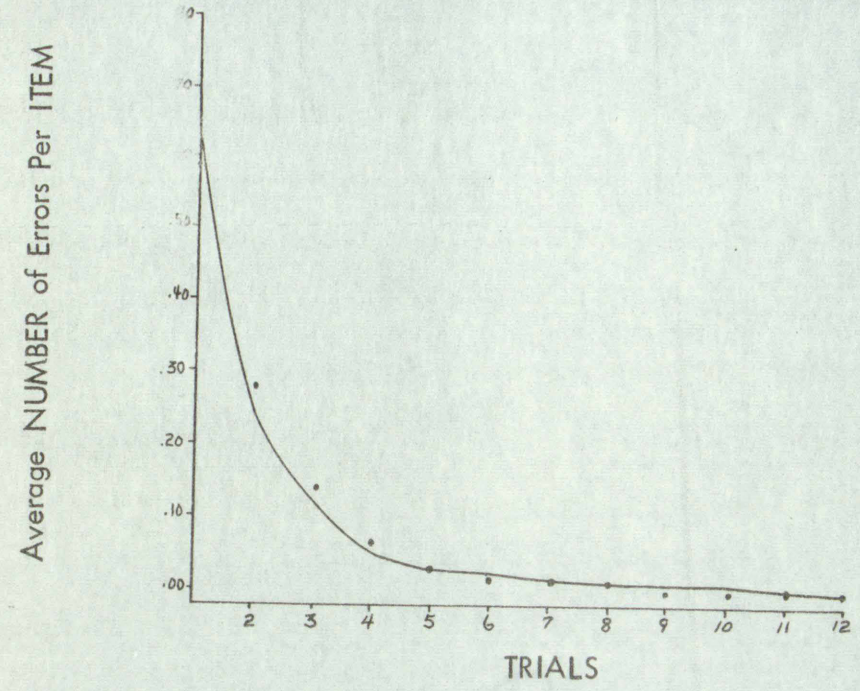


Figure 4. Average number of errors per item plotted as a function of trials for the S_L group. (The smooth curve represents predicted values; the dots near the curve represent the corresponding observed values.)

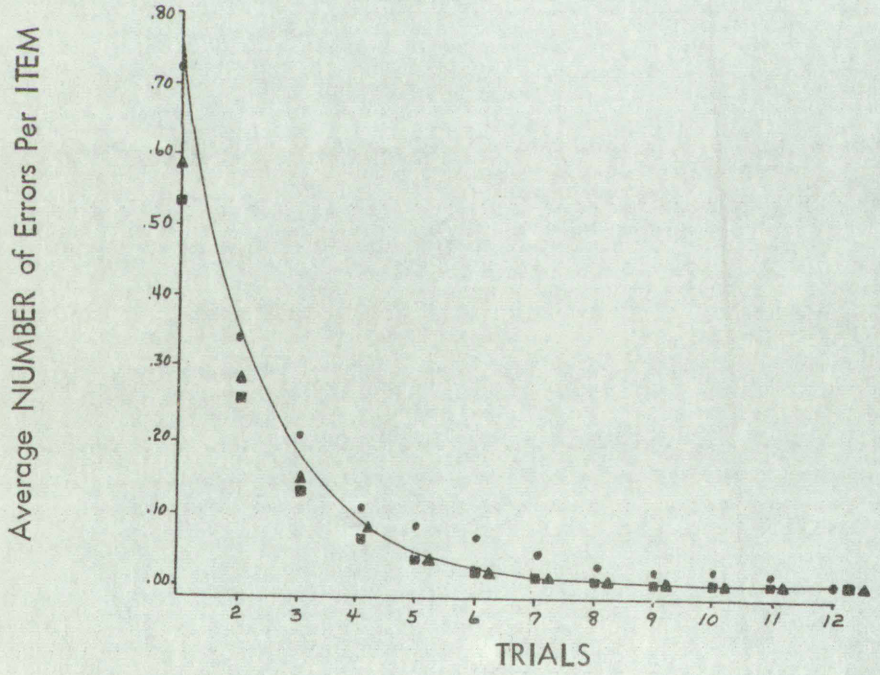
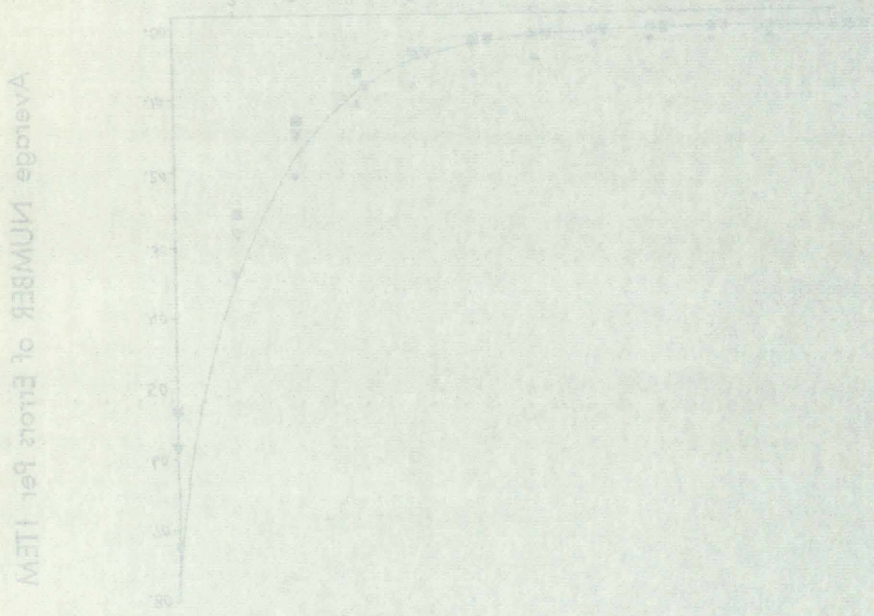


Figure 5. Average number of errors per item plotted as a function of trials for the S_O, S_M, and S_L groups. (The smooth curve represents predicted values of the S_O group; the dots, squares, and triangles represent the corresponding observed values for the S_O, S_M, and S_L groups, respectively.)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Support for the assumption that the learning process, expressed as the rate parameter c, underlying the hook-up stage of the acquisition task is equivalent to the same process underlying the transfer task is seen in Figure 5. The solid curve which was obtained by solving Equation 1 across trials for the S_0 group has sufficient generality for the observed values for the two transfer groups. The small triangles represent the observed values for the S_L group; the squares illustrate the empirical values for the S_M group; and the observed values for each trial of the S_0 group are expressed by the small, opened dots. A comparison of Figure 1 (p. 7) with Figure 5 indicates that the hypothetical relationship predicted for the control and transfer groups has been confirmed, thus supporting the two assumptions made earlier. Figure 5 not only supported the assumptions regarding the "hook-up" phase of paired-associate learning in an acquisition and transfer situation but also provided additional confirmation of the generality of the association model to a similar set of behaviors. Thus, Bower's model has sufficient power to describe and predict the on-going behaviors of Ss in a paired associate transfer task.

Since the values calculated for n in Equation 7 demonstrated that they held across trials for both experimental groups, the data is suggestive that these values (1.33 and 1.47 for S_L and S_M, respectively) are empirical constants which may be utilized to predict results which employ the same learning materials and homogeneous population of subjects.

To determine if these values of n warrant the stature of empirical constants, an experiment would only require an alteration in the number of responses available. The only term in Equation 1 which would change is that expressing the probability of an incorrect guess. Since the model assumes that each item and each subject can be characterized by c, the theory constrains c to be the same for all conditions. Predicted average number of errors per item for the transfer groups could be determined prior to experimentation. An indication of the predictive success of the model and the role of n could readily be determined by calculation of the empirical points.

Empirical Analysis of the Data

Recently, several transfer studies (Ellis, 1958, 1960) have employed different criterion measures in order to assess the role of a parameter on various stages of performance. A dimensional analysis of this kind serves a twofold purpose. First, it permits a determination of the most appropriate criterion measure for a particular set of conditions. Secondly, such an approach is highly useful for a theoretical analysis, for with a systematic examination of the effect of a single parameter on a host of dependent variables an investigator is able to isolate significant effects in his search for functional relationships. The subsequent section, then, is devoted to a dimensional analysis of the "hook-up" phase of verbal transfer in the hope that various relationships will emerge.

Transfer Measures as First Trial Performance. Since Ss during the initial task learned different lists, it was necessary to determine if differences existed among these groups. If significant differences were obtained, then no conclusion could be made regarding the effects of stimulus similarity on first trial performance of the transfer task without appropriate statistical control. The means and standard deviations for the three groups on the initial list are presented in Table 5.

TABLE 5

MEAN CORRECT RESPONSE ON THE FIRST ANTICIPATION TRIAL OF THE INITIAL TASK

GROUPS					
Low Similarity (S_L)		Median Similarity (S_M)		Control (S_0)	
M	SD	M	SD	M	SD
2.21	1.61	2.43	1.12	2.29	1.10

The means observed in Table 5 were atypical due to an artifact of the experimental procedure. Prior to learning the list, the Ss were given the responses and were instructed to guess at the beginning of the task. Since there were four responses available and eight stimulus items in each list, the probability of correctly guessing on the first trial was two out of eight, i.e., the theoretical mean, in this instance, would be 2.00. Observation of the means of all the groups

Low Solidarity (θ_L)		Medium Solidarity (θ_M)		Control (θ_C)	
M	SD	M	SD	M	SD
8.81	1.61	8.45	1.18	8.09	1.12

indicated only a slight divergence from those means expected by chance.

Although inspection of the means indicated that it was highly unlikely for differences to exist among the groups, an analysis of variance was performed on the number of correct responses in order to determine if significant differences were, in fact, present. An F ratio of .144 (df = 2,39) clearly revealed that the three groups were essentially equivalent. Cochran's Test revealed that the assumption of homogeneity of variance was met.

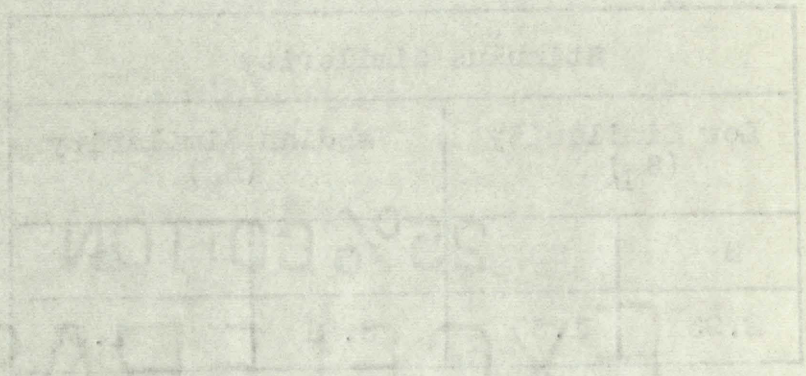
The results of first trial performance for the two transfer groups are shown in Table 6. The means for both groups are somewhat greater than those obtained from the initial list, even though there appeared to be only a small difference in the expected deviation between the two means.

TABLE 6

MEAN CORRECT RESPONSES ON THE FIRST ANTICIPATION TRIAL OF THE TRANSFER TASK

Stimulus Similarity			
Low Similarity (S_L)		Median Similarity (S_M)	
M	SD	M	SD
2.93	1.33	3.21	1.57

Since Ellis (1958, 1960) used per cent transfer measures in analyzing the effect of stimulus similarity on the transfer



tasks, an identical procedure was employed here in order to affect a direct comparison. The measure of transfer, computed from the mean correct responses on the first anticipation trial, was obtained from Table 6.

The transfer formula employed was as follows:

$$\text{Per cent Transfer} = \frac{E - C}{C} \times 100$$

where E equals the mean number of correct responses on first trial performance for the transfer task and C equals the mean number of correct responses on the first trial of the initial list for the control group (S_0). Per cent transfer for the group with prior training on the low similarity list was 27.9. Per cent transfer for the S_M group was 40.1.

Statistical analysis of the data revealed that no significant difference existed between the two transfer groups. A one-tailed t of 1.1081 (df = 26) indicated that no differential effect occurred as a result of stimulus similarity. One possible explanation for no differential facilitation between the two groups may lie in the choice of only two levels of stimulus similarity employed in this experiment. The mean scale values for the moderately similar stimulus items on the initial list were 2.6. The second experimental group ($S_L - R_0$) was presented with adjectives of low similarity to those on the transfer task ($S_0 - R_0$) having a mean scale value of 4.2. Thus, the stimulus items on the initial lists may have been too similar to produce any differential effect between the groups when they learned the second list.

Transfer Measured as Trials to Criterion. In a verbal paired-

associate task, Ellis (1958) found that stimulus similarity did not differentially facilitate transfer when transfer was measured in terms of a perfect mastery criterion. Contrary results, however, were obtained in a perceptual transfer experiment. Ellis and Burnstein (1960) observed that transfer was differentially facilitated when stimulus similarity was employed as a parameter. They tentatively hypothesized that this difference in their results may be interpreted as a relative persistence of the associative stage over time in the perceptual task because the responses employed in the 1960 experiment had lower association values than the response items of the earlier study. The persistence of the "hook-up" phase, they conjectured, may permit the differential effect of stimulus similarity to function longer in the course of the transfer task. If negative results were obtained from the present study which virtually eliminated the first phase of the learning process, then additional support of their position would be introduced.

Table 7 represents the means and standard deviation of the three groups on the initial list. Inspection of the table reveals that the means were virtually identical.

TABLE 7

MEAN TRIALS TO CRITERION ON THE INITIAL TASK

Groups					
Low Similarity (S_L)		Medium Similarity (S_M)		Control (S_0)	
M	SD	M	SD	M	SD
15.07	5.64	18.71	10.47	16.92	8.36

An analysis of variance was performed on the data presented in Table 7 in order to determine if the means differed significantly. If Ss had learned the lists at different rates, then an analysis of covariance would have been necessary to partial out differential effects among the groups. The results of the analysis of the variance showed that no significant differences existed among the three groups when trials to criterion was employed as the criterion measure. An F of .635 (df = 2,39) failed to obtain significance at the .05 level of confidence. Cochran's C Test indicated that the assumption of homogeneity was met.

The means and standard deviations for the two transfer groups are presented in Table 8. An inspection of the means suggests that hardly any difference exists between the two groups when trials to perfect mastery is employed as a criterion measure. Although the S_M group's mean is somewhat greater than that of the S_L group, the difference is quite small. It should be noted that the S_L group achieves a criterion of perfect mastery faster than the S_M group; this difference in rate is reflected in the slope constants of two groups which will be discussed later in this section. It suffices to say that, since S_L learned its initial list faster than S_M, the differential effect of stimulus similarity on the transfer of the two groups may have been masked by the slower learning rate of the S_M group.

TABLE 8

MEAN TRIALS TO CRITERION ON THE TRANSFER TASK

Stimulus Similarity			
Low Similarity (S_L)		Medium Similarity (S_M)	
M	SD	M	SD
8.29	3.43	8.79	3.57

Per cent transfer was computed by the application of the following formula:

$$\text{Per cent transfer} = \frac{C - E}{C} \times 100$$

where C equals the mean number of trials to criterion for the control group, and E equals the mean number of trials to criterion for the experimental group. Because of the instructional procedure employed, the guessing probabilities of the Ss remained approximately constant throughout the learning of the task. Therefore, the difficulty cited earlier, i.e., C was of such a value that it decreased the amount of transfer, still persisted in the treatment of the data when trials to criterion were employed as the dependent variable.

The S_M group's mean per cent transfer was 48.1. This was only slightly higher than the 51.0 per cent transfer observed in the S_L group. A one-tailed t test performed on the per cent transfer measures indicated that no significant differences existed between the group means. A t of .0753 (df = 26) failed to attain significance at the .05 level. Since no significant differences were obtained between S_L and

S_M on transfer performance, the results indicated that, when conditions exist which do not permit a persistence of the "hook-up" phase, the differential effects of stimulus similarity failed to function throughout the transfer task. This finding supported the assumption of Ellis and Burnstein (1960).

Transfer as Measured by Error Performance. The number of errors made throughout the transfer task was the third transfer measure examined. This measure had special relevance to the assumption made earlier, viz., that, if the stimulus items on the transfer task are sufficiently similar to those of the original task, then the proportion of items already conditioned on the first trial of the transfer task would be a function of the degree of inter-task stimulus similarity. Given this assumption and the E's observation that Ss after giving an erroneous response on the first trial would continue to make the same incorrect response to the same inappropriate stimulus for six to ten subsequent trials--thus supporting in a non-analytical fashion the finding of Rock (1957) that the formation of an association is one trial--it might be expected on an a priori basis that the S_L group would make more errors on the transfer task than the S_M group.

The mean number of errors for the three groups on the initial task is presented in Table 9. Although only a slight difference occurs between the S_L and S_O groups, a greater discrepancy exists between these groups and the mean obtained for the S_M group.

TABLE 9

MEAN NUMBER OF ERRORS ON THE INITIAL TASK

Groups					
Low Similarity (S_L)		Medium Similarity (S_M)		Control (S_O)	
M	SD	M	SD	M	SD
43.29	20.14	47.29	29.94	44.86	29.26

In order to ascertain whether or not the means of these groups differed significantly from one another, an analysis of variance was performed. The results of the statistical procedure revealed that no significant differences existed between the groups on error performance. An F of .072 (df = 2,39) indicated that no clear-cut differences in mean errors were present. Cochran's Test indicated that the assumption of the homogeneity of variance was met.

Table 10 lists the mean number of errors for S_M and S_L on the transfer task. Inspection of the means reveals that stimulus similarity appeared to have a differential effect on error performance. That is, when the degree of inter-task similarity increased, the probability of an error on the second task decreased.

TABLE 10

MEAN NUMBER OF ERRORS ON THE TRANSFER TASK

Stimulus Similarity			
Low Similarity (S_L)		Medium Similarity (S_M)	
M	SD	M	SD
18.36	8.80	16.36	9.57

TABLE 9

MEAN NUMBER OF ERRORS ON THE INVERTED TASK

Groups					
Low Similarity ($\bar{X}_L$)		Medium Similarity ($\bar{X}_M$)		Control ($\bar{X}_0$)	
N	SD	N	SD	N	SD
60.89	30.14	87.29	39.94	44.88	28.45

The transfer formula employed to compute per cent transfer in terms of errors was identical to that used in obtaining per cent scores when trials to criterion was examined as the dependent variable.

The mean per cent transfer for the S_M group was 63.5. A slight reduction was found with the S_L group whose mean per cent transfer was 59.1.

Statistical analysis of per cent transfer (measured in terms of errors) indicated that no significant differences existed between the two groups. A t of 1.0945 (df = 26) failed to attain any level of significance. The supposition that the proportion of items conditioned on the transfer task is a function of the number of stimulus elements that the transfer task has in common with the initial task was not supported by the analysis.

Empirical Slope and Intercept Constants. In order to determine if the slope and intercept constants were consistent with the assumptions stated earlier, these values were calculated for the initial and transfer tasks. Although the empirical values are neither necessary nor sufficient conditions for the assumptions regarding transfer, results suggestive of these assumptions would provide additional support for the suppositions and hence, the theory. Also, since the theory employed a different dependent variable, the criterion measure used here--proportion of correct responses--presented the opportunity to ascertain if different criterion measures would produce different effects.

The empirical slope and intercept constants for the control and transfer groups on both the initial and transfer tasks were obtained via the reduction process (Lewis 1960). A logarithmic equation was found to yield the line of best fit for all groups. The general form of the equation is given by

$$Y = a \log X + b$$

where Y = some dependent variable; a = the slope constant of the learning curve, i.e., the rate at which a task is learned; b = the intercept constant of the curve, that point of initial status; and X = any given trial. The data which is presented in Tables 11 and 12 illustrate the results of the analysis. Since the assumptions regarding the associate stage of transfer are not related in any logical fashion to an empirical analysis, no statistical test were employed in order to determine if significant differences exist among the groups. Rather, the approach here is essentially descriptive and, as such, attempts no more than to produce results which are suggestive of the theoretical suppositions formulated earlier.

TABLE 11

SLOPE CONSTANTS FOR EXPERIMENTAL AND CONTROL GROUPS ON INITIAL AND TRANSFER LISTS

		Initial List	Transfer List
Experimental Groups	S_L	.595	.632
	S_M	.494	.508
Control Group	S_o		.515

The slope constants for the control and transfer groups for both initial and transfer performance are presented in Table 11. Inspection of the constants for the experimental groups on the initial list indicates that the S_L group learned its list at a greater rate than the S_M group. The rates on the transfer list for the experimental groups show that both groups learned the second list at a higher rate than the previous lists. Comparison of the two experimental groups with the control group on the transfer task appears to indicate an inverse relationship between stimulus similarity and the rate at which the transfer task was learned, i.e., as stimulus similarity increases, the rate of learning on the transfer task decreases. This finding is identical to that obtained by Ellis (1958). However, it is difficult to determine whether the observed relation is valid here. Since the transfer paradigm does not permit the E to determine if differences in learning rate on the transfer task arose because of differential learning ability between the groups or whether one list (S_M) has a higher degree of intra-list similarity than the other (S_L). Consequently, no unequivocal assertions can be made. Nevertheless, the slope constants appear sufficiently similar to offer indirect, descriptive support of the assumption that the processes which underlie the associative stage of a paired-associate acquisition and transfer task are equivalent.

TABLE 12

INTERCEPT CONSTANTS FOR EXPERIMENTAL AND CONTROL GROUPS ON INITIAL AND TRANSFER LISTS

		Initial List	Transfer List
Experimental	S_L	.185	.358
Groups	S_M	.271	.453
Control Group	S_O		.250

The intercept constants for the three groups are presented in Table 12. Since Ss were instructed to respond with one of four responses available, the probability of a correct guess given the number of available responses was .250. Inspection of the intercept constants for the two experimental groups on the initial task shows that their intercepts differed only slightly from the expected a priori value. The control group's (S_O) observed intercept constant was the same as the predicted value. The intercepts of the S_L and S_M on the transfer task were .358 and .453, respectively. The constants for these groups were in the direction predicted from an assumption formulated in the preceding section, viz., that the proportion of items conditioned on the first trial of the transfer task is a function of the similarity of stimulus elements between the tasks. A comparison of the intercept constants for the two groups on both initial and transfer tasks indicated, however, that differences on the transfer task may have been a result of initial differences on the first list.

SUMMARY AND CONCLUSIONS

The purpose of this experiment was to determine if a mathematical model which was developed for the associative stage of a paired-associate acquisition task was capable of generating results which would relate to data obtained in an investigation of the associative stage of a paired-associate transfer task.

In order to test the model, two assumptions were necessary:

a) The learning process which underlies the "hook-up" phase of a paired-associate transfer task is equivalent to the process which occurs during the same stage of a paired-associate acquisition task. This assumes that the rate parameter of the transfer task must be identical to the slope constant obtained from a paired-associate acquisition group.

b) If the items on the transfer task are sufficiently similar to those of the original task, then on Trial 1 of the transfer task a certain proportion of items will already be conditioned; other items, however, will not possess sufficiently similar properties to the original stimuli and will fail to generalize. This assumption predicts a change in the intercept constants for the transfer groups.

Forty-two undergraduates from the University of New Mexico served as Ss. The two experimental groups learned different initial lists and all groups (both experimental and

control) learned an identical second list. Inter-task stimulus similarity was varied by using adjectives scaled by Haagen (1949) and Ellis (1958). The response members employed were the integers 1, 2, 3, and 4.

The experiment examined the effects of stimulus similarity on mean number of correct responses on the first anticipation trial of the transfer task, on trials to criterion, on error performance, and on the empirical and theoretical slope and intercept constants.

The results indicated:

1. Assumption (a) was verified by employing the slope constant obtained from the control group in predicting values for the two transfer groups, i.e., the rate parameter, c, which is the mathematical expression for the learning process, possessed sufficient generality to be used in generating the theoretical transfer curves.

2. The assumption that the proportion of items conditioned on Trial 1 of the transfer task is contingent upon inter-task stimulus similarity was confirmed with the S_M group's intercept value being the lowest obtained and the S_L group's intercept constant lying between the values of S_O and S_M.

3. The predicted and observed average total number of errors per item for the experimental and control groups showed that the theory is an adequate one for predicting the observed values.

4. Empirical slope constants offered indirect support for the assumption that the learning process which underlies

the "hook-up" stage of a paired-associate acquisition and transfer task is equivalent.

5. Empirical intercept constants were in the direction predicted from the assumption that the number of items conditioned on Trial 1 of the transfer task is a function of inter-task stimulus similarity.

6. When number of correct responses on the first trial of the transfer task, trials to criterion, and error performance were employed as the dependent variables, no differential effect was observed between the two transfer groups. The results indicated that either the instructional procedure, transfer paradigm or the scale values of the stimulus items were responsible for obscuring any significant differences among the transfer groups.

7. An extension to the above experiment was proposed in order to determine if the trial values obtained for the S_M and S_L groups warrant the stature of empirical constants. Employing the same learning materials and homogeneous population of Ss, the values should predict the transfer performance of a variety of groups with differing numbers of responses available.

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[illegible]

Underwood, R.L. [illegible]
[illegible]
Interface [illegible]

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APPENDICES

APPENDIX A

Mathematical Derivation of Equation 2.

The expected total number of errors per item before perfect learning is expressed by the quantity $\sum_{n=1}^{\infty} q_n$.

Since $q_n = (1 - \frac{1}{N})(1 - c)^{n-1}$

and $\sum_{n=1}^{\infty} q_n = \sum_{n=1}^{\infty} (1 - \frac{1}{N})(1 - c)^{n-1} = (1 - \frac{1}{N}) \sum_{n=1}^{\infty} (1 - c)^{n-1}$, [1]

then the $\sum_{n=1}^{\infty} q_n$ may be obtained by applying the formula for the sum S_n of an infinite geometric series to $(1 - c)^{n-1}$ and multiplying the result by $(1 - \frac{1}{N})$.

$$\lim_{n \to \infty} S_n = \lim \frac{a(1 - r^n)}{1 - r} \qquad [2]$$

Substituting $(1 - c)$ for r and 1 for a in Equation [2], we obtain

$$\lim_{n \to \infty} \frac{1\left[1 - (1 - c)^n\right]}{1 - (1 - c)} = \lim_{n \to \infty} \left[\frac{1}{1 - (1 - c)} - \frac{1(1 - c)^n}{1 - (1 - c)}\right] =$$

$$\lim_{n \to \infty} \left[\frac{1}{c} - \frac{(1 - c)^n}{c}\right]$$

As the exponent n becomes infinitely large in the expression $\frac{(1 - c)^n}{c}$, the value of the expression approaches

zero. Therefore,

$$\lim_{n \to \infty} \left[\frac{1}{c} - \frac{(1 - c)^n}{c} \right] = \frac{1}{c} - 0 = \frac{1}{c}$$

Substituting $\frac{1}{c}$ in Equation 1, we get

$$\sum_{n=1}^{\infty} q_n = (1 - \tfrac{1}{N}) \sum_{n=1}^{\infty} (1 - c)^{n-1} = (1 - \tfrac{1}{N}) (\tfrac{1}{c}) = \frac{1 - \frac{1}{N}}{c}$$

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APPENDIX B

STIMULUS RESPONSE PAIRS USED IN THE

SECOND LIST

Stimulus Item	Response Item
AGILE	1
EMPTY	2
STICKY	3
TRIFLING	2
COMPLETE	4
BELOVED	3
LIQUID	1
URGENT	4

*Since the response members were the same for the two initial lists, they are presented here as being paired with only the standard stimulus items.

APPENDIX C

STIMULUS ITEMS USED IN THE EXPERIMENT

SHOWING WASHINGTON AND IOWA SCALE VALUES

Standard Word	Moderate (S_M) Similarity	Scale Values		Low (S_L) Similarity	Scale Values	
		Iowa	Wash.		Iowa	Wash.
AGILE	LIVELY	2.1	3.3	TRIPPING	4.5	6.2
EMPTY	HOLLOW	2.4	3.7	YAWNING	4.3	6.1
SICKLY	INFIRM	2.9	3.3	BEDFAST	3.9	4.5
TRIFLING	PALTRY	2.3	3.0	CHILDISH	4.4	5.4
COMPLETE	UTTER	3.1	4.4	PERFECT	3.5	4.5
BELOVED	PRICED	2.8	3.2	PREFERRED	4.2	4.4
LIQUID	FLOWING	2.7	4.0	LIMPID	4.2	5.4
URGENT	ACUTE	2.3	2.5	CRYING	4.8	6.2

APPENDIX D

AVERAGE NUMBER OF ERRORS PER ITEM AS A FUNCTION OF TRIALS FOR THE S_O, S_M, AND S_L GROUPS

Trials	Control Group (S_O)		Moderate Similarity Group (S_M)		Low Similarity Group (S_L)	
	Predicted	Observed	Predicted	Observed	Predicted	Observed
1	.75	.71	.59	.53	.63	.59
2	.36	.34	.22	.26	.24	.29
3	.18	.21	.11	.12	.13	.14
4	.09	.11	.05	.06	.05	.07
5	.04	.09	.02	.03	.03	.03
6	.02	.07	.02	.02	.03	.02
7	.01	.04	.01	.01	.01	.01
8	.01	.03	.01	.01	.01	.01
9	.00	.02	.00	.00	.01	.00
10	.00	.02	.00	.00	.01	.00
11	.00	.01	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00