THE EFFECT OF SEQUENCE OF PRESENTATION OF SIMILAR ITEMS ON THE LEARNING OF PAIRED ASSOCIATES

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INTRODUCTION

A number of recent studies have demonstrated the importance of the similarity of stimulus items for the learning, retention, and transfer of paired-associate lists. In general, it has been found that the greater the degree of similarity between items, the slower is the learning and the smaller the amount of retention. von Restorff (11) accounts for this type of result by the use of the concept of *isolation*. Items which are surrounded by very dissimilar material, i.e., isolated items, are easier to learn and to retain than those surrounded by very similar or 'homogeneous' material, presumably because they are easier to perceive. On the other hand, Gibson (1) conceives of this type of learning situation as one which involves the establishment of a number of discriminative responses to items which potentially exhibit some degree of *stimulus generalization*, and which become differentiated, as learning proceeds, through the mechanism of differential reinforcement. According to this hypothesis, the greater the similarity between items in a list, the greater will be the tendency for them to evoke responses primarily associated with other similar items, because of the existence of generalization gradients between the members. In one of Gibson's experiments (3) it was found that a group of 12 relatively dissimilar nonsense forms required fewer trials for learning and showed greater retention after 24 hours than did groups of 12 highly similar forms.

The experiment reported in the present paper does not make a direct and unambiguous contribution to the solution of this theoretical controversy. It does, however, test the utility of Gibson's hypothesis under a particular set of learning conditions to which it might be expected to apply. Among the results of the experiment cited above (3) is the finding that while the number of correct responses shows a steady increase from beginning to end, generalization, as measured by number of overt confusions of similar items, increases at first, passes through a maximum, and subsequently decreases. It is possible to draw the implication that this latter process, because it does involve the expression of a large number of overt errors during the early stages of learning, thereby makes possible a most effective application of differential reinforcement. In other words, perhaps this initial 'confusion' is itself a factor which tends to speed up the acquisition of discriminative responses by fostering the elimination of overt errors. If this view is correct, it may be expected that any condition which serves to emphasize or to speed up this initial increase in generalization with a given set of learning material, will tend also to bring about more rapid acquisition of the correct differential responses to the stimuli presented.

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One of the conditions which might be supposed to have an effect upon the time of occurrence of initial generalization is the sequence of presentation of paired-associate items. Different sequences can be arranged to give different degrees of emphasis to the similarities of the stimulus items within a group (i.e., different sequences yield different degrees of isolation). The experiment to be described is concerned with the effect of different orders of presentation of items in a single group containing both very similar and very dissimilar components, on the rate of learning of the total group. In a single list of this sort, the items may be arranged to emphasize what von Restorff termed 'isolation' by placing the items in sequence so that the most similar ones are separated maximally by a number of non-similar items. On the other hand, the items may be arranged in such a way as to emphasize the similarity of certain members of the total group, by having the items of the greatest similarity always occur close together in sequence. The latter sort of arrangement should, Gibson's analysis implies, cause the greatest amount of generalization to occur nearer the beginning of the learning process than would be the case in the isolated arrangement. Our hypothesis is that such earlier-occurring generalization should lead to more rapid learning of the material.

In general, studies of paired associate learning have not concerned themselves with effects produced by varying orders of presentation. Instead, care has been exercised in most instances to vary the order of presentation of items from trial to trial in random fashion, in order to distinguish such learning from serial learning, in which subjects are required to reproduce the sequential arrangement of items in a learned list. An exception is the experiment of McGeoch and McKinney (9), which compared the rate of learning of paired nonsense syllables and nouns under conditions of unvarying order of presentation with the rate of learning of the same material when the sequence of items was varied from trial to trial. The former condition yielded the faster learning. However, in contrast to this study, the experiment to be reported herein is not concerned with the learning of *serial order* of items. In order to avoid such learning, recall is always measured with the items in random order, whereas the presentation or 'learning' trials are conducted with orders which emphasize similarity or dissimilarity among the items.

The problem investigated here is one which arose in connection with a number of verbal-type skills in the armed forces during World War II. For example, training in aircraft recognition involved the learning by students of a name or designation for each of a group of more or less similar airplane shapes. One of the procedures employed in such training was that of presenting each new item (plane) in conjunction with another item of very dissimilar shape. This method was one, then, in which the attempt was made *not* to present the most similar items together, at least during the same instructional period. It bears some resemblance to the condition which von Restorff terms 'isolation' of items, since it was accomplished by accompanying each item with a very dissimilar item. Although it is readily seen that initial confusion is avoided by such a procedure, this fact does not enable one to predict whether or not the method is an efficient one so far as the learning of the total group of items is concerned. The practical effectiveness of this sequence of presentation for producing rapid learning was compared experimentally with a method which involved the presentation of two very similar items together during the same instructional period (4). Neither procedure was found to have an advantage in producing more rapid learning. It is clear, however, that the two sequences employed in this experiment did not permit a comparison of the condition in which *all* the most similar items are presented together with a condition in which a maximum degree of separation or isolation is given to *all* the most similar items.

Essentially the same problem arose in connection with the training of code reception, in which a group of auditory characters, varying in similarity to each other, was to be learned. Both Spragg (12) and Keller (7) raised the question of the relative efficiency for learning of presenting groups of very similar code characters together in sequence, versus a procedure involving the presentation of closely similar characters with a maximum degree of separation. In these instances, too, no experimental answer was obtained to this question.

Statement of Problem

The present experiment is concerned with measuring the extent and time of occurrence of generalization, and the rate of learning of visual form-nonsense syllable pairs when they are presented under four conditions which represent different sequential arrangements of these items. In one condition, closely similar items are always presented together in sequence; in a second condition, the most similar items are always presented with the maximum degree of separation by dissimilar items in sequence. In order to distinguish the effects of grouping similar items from the effects of grouping as such, a third condition is employed in which sub-groups of non-similar items are always presented together in sequence. The fourth condition provides a control in which the items are presented in varying random order from trial to trial. The first condition, in which the items are presented in a way which emphasizes their similarity, might be expected to produce the greatest degree of generalization, as measured by errors of confusion between similar items, at the beginning of the learning process. On the other hand, if maximum separation is given to closely similar items, as in Condition 2, generalization should tend to be delayed, and to reach its highest point somewhat later during the course of learning. The experiment to be reported is designed to test these predictions, as well as to discover what, if any, relationship exists between the time of occurrence of maximum generalization and the rate of learning of the total material.

Procedure

Materials.—A group of 12 nonsense forms was constructed, comprising four different sub-groups of three closely similar forms. Some of the forms employed by Gibson (2) were used to make up this group. Gisbon constructed three lists of 12 forms each, in which the corresponding forms of the first and second list showed a high degree of similarity. The forms used in the present experiment were selected from these first two lists. The third member of each sub-group was constructed to be very similar to, though not indistinguishable from, the other two. No attempt was made to measure independently the degree of generalization among the three forms of each sub-group. Gibson's results, however, make it reasonable to assume that a high degree of generalization existed among them. Each form was paired with a three-letter nonsense syllable from the list compiled by Hull (5). Syllables having the lowest degrees of association value were used. The form-syllable pairs are shown in Fig. 1.

The list of 12 members was exposed in four different sequences. Allowing the letters A, A_1, A_2, B, B_1, B_2, etc., to stand for the four sub-groups of three-membered similar items, these

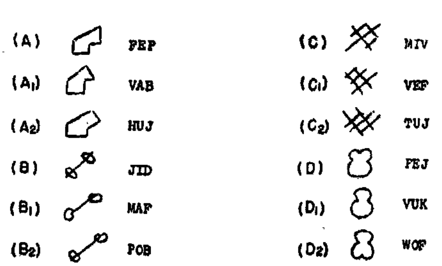

Fig. 1. The 12 nonsense forms and the syllables to be associated with them

conditions were as follows: *Condition 1:* The most similar items were always presented together in sequence. On the first trial the order of presentation was A, A_1, A_2, B, B_1, B_2, C, C_1, C_2, D, D_1, D_2. On subsequent trials the order was rearranged in such a way as always to keep the three closely similar items in each sub-group together. For example, on the second trial the items were presented in this sequence: B, B_2, B_1, D_1, D, D_2, C_1, C_2, C, A_2, A, A_1. *Condition 2:* In this condition the items were arranged so that the most similar forms would have a maximum degree of separation in sequence. The first trial of this condition was as follows: A, B, C, D, A_1, B_1, C_1, D_1, A_2, B_2, C_2, D_2. On subsequent trials the order was changed, but each similar form was separated by three dissimilar forms in sequence. The second trial, for example, was given in this order: C_1, B, D_2, A, C_2, B_1, D, A_1, C, B_2, D_1, A_2. *Condition 3:* This condition was used in order to determine the effect of presenting the items in groups of three, as was done in Condition 1, without, however, having these groups contain closely similar items. Four arbitrary groups of three dissimilar items each were consequently arranged. The three items of each group were always presented together in sequence. The first trial of this condition was presented in the following order: C_1, B, D_2, A, C_2, B_1, D, A_1, C, B_2, D_1, A_2. In subsequent trials the three members of each (arbitrary) sub-group were rearranged, and the order of the sub-groups themselves was changed, As in Condition 1, however, the three members of each arbitrary sub-group were always presented together in sequence. For example, the second trial in this condition was presented in the following order: A, B_1, C_2, D_1, B_2, A_2, A_1, C, D, D_2, C_1, B. *Condition 4:* In this condition the forms were always presented in random order. The order for each presentation trial was the same for each subject. These orders were determined before the experiment began by the use of a table of random numbers.

The lists were made up in accordance with the principles described above by pasting the mimeographed form-syllable pairs onto a sheet of paper cut to the proper size for the memory drum. On each trial, the forms were presented in the same order for each subject who served under a particular condition. A recall trial, in which the forms were exposed without the accompanying syllables, was conducted after each presentation trial in all of the conditions. The stimuli were always presented in random order during recall trials. The particular random order used on each recall trial was the same for all subjects under all conditions. The forms and their associated nonsense syllables were presented to the subjects on a memory drum which brought each stimulus member into view at the rate of one every two sec.

Subjects.—The subjects used in the experiment were undergraduate women college students who had volunteered for the task. They had studied psychology in at least one course, but were unaware of the purpose of the experiment, except for the knowledge that learning was being measured. Fifteen matched subjects were obtained for each condition of the experiment. The subjects in these four groups were matched on the basis of a learning score, number of syllables correctly recalled on the fourth recall trial of a practice list of form-syllable members which was learned before the experiment proper was begun. This practice list was made up of 12 nonsense forms which were very dissimilar to those used in the experiment itself.

Experimental Procedure.—During each session the subject observed the forms and syllables exposed through the window of a memory drum which rested on a table, in front of which he was seated. He began by learning the practice list, exposed to him in four presentation trials, each one of which was followed immediately by a recall trial. The orders of items on both presentation and recall trials were the same for each subject, but varied from trial to trial in accordance with a predetermined random order. The subjects' responses on each recall trial were recorded by the experimenter. The number correct on the fourth recall trial was used as a measure of the amount of learning which had taken place. The following instructions were given to the subject at the beginning of the 'practice' learning:

> You will be shown a group of forms, each one paired with a nonsense syllable. Study these pairs so that when the form is shown alone, you can say the appropriate syllable. You will be shown only one pair at a time. Do not try to learn these pairs in any particular order, because the order will be changed every time. The point is to associate a particular syllable with the form with which it always appears. After every presentation of the forms paired with the syllables, you will be shown the forms by themselves in order to see whether you remember the appropriate syllable or not. If you do remember the syllable, tell me and I shall write it down.

After a five-min. rest period the main experiment was begun. The following instructions were given:

Now you will be shown another group of forms each one paired with a nonsense syllable. Proceed just as you did before. Do not try to learn the pairs in order because the order will be changed every time. This time we will continue the learning for a greater number of trials.

Each subject was given 14 learning trials. Three subjects out of the total number achieved a perfect recall trial on the fourteenth trial.

Results

Learning in terms of syllables correct.—The average number of syllables correct on each of the 14 trials, together with the standard deviation of each value, is given in Table I. These values are plotted as learning curves for the four groups in Fig. 2.

It may be seen that learning follows esentially the same course in each group for at least 10 trials. Actually, no significant differences in number of syllables correct appear between the scores of any of the groups on the first 11 trials. Beginning on the 11th trial, the learning of Group 1 begins to exhibit a rate which is faster than that of any of the other groups. This advantage occurs in a group which learned the 12 form-syllable pairs under conditions in which the three highly similar items of each sub-group were always presented together. On the other hand, Group 2, which learned the material presented in such a way that each similar item was given the maximum degree of separation, exhibits a curve which is essentially the same as that of a control group (Group 4) in which random orders of presentation were used. The differences which appear in favor of Group 1 on the last two or three trials cannot be attributed to the grouping of syllables (independently of their similarities), since Group 3, for which grouped presentation of dissimilar items was used, exhibits no faster learning than the control group.

In terms of number of syllables, the differences themselves are not large, though the trend seems fairly clear.

TABLE I

Means and SD's of Number of Syllables Correct on Each of Fourteen Learning Trials for the Four Groups of the Experiment

Group 1, similar forms presented together; Group 2, similar forms given maximum separation; Group 3, sub-groups of dissimilar forms presented together; Group 4, random presentation. N = 15 for each group.

Trial	Group 1		Group 2		Group 3		Group 4	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	0.73	0.86	0.60	0.71	0.47	0.50	0.60	0.88
2	1.20	1.17	0.60	0.80	1.27	0.99	1.20	1.47
3	1.47	1.20	1.67	1.19	1.67	1.44	1.87	1.58
4	2.33	1.99	2.00	1.26	2.67	1.85	2.80	1.47
5	3.80	2.32	2.87	1.82	3.20	1.72	2.13	2.54
6	3.53	2.10	3.20	1.51	3.67	2.14	3.40	2.73
7	4.20	2.01	3.40	1.58	3.80	1.76	3.93	3.03
8	4.87	2.55	4.07	1.56	4.13	1.86	4.67	2.59
9	5.40	2.47	4.33	2.31	4.27	2.48	5.20	3.15
10	6.00	3.10	4.80	2.64	4.87	2.61	5.40	3.05
11	6.20	2.74	5.53	2.88	5.80	1.94	5.53	3.01
12	7.20	3.39	5.80	2.83	6.20	2.81	5.60	3.65
13	7.67	3.82	5.80	2.59	6.20	3.02	5.93	3.83
14	8.20	3.27	6.67	2.80	6.40	3.01	6.47	3.79

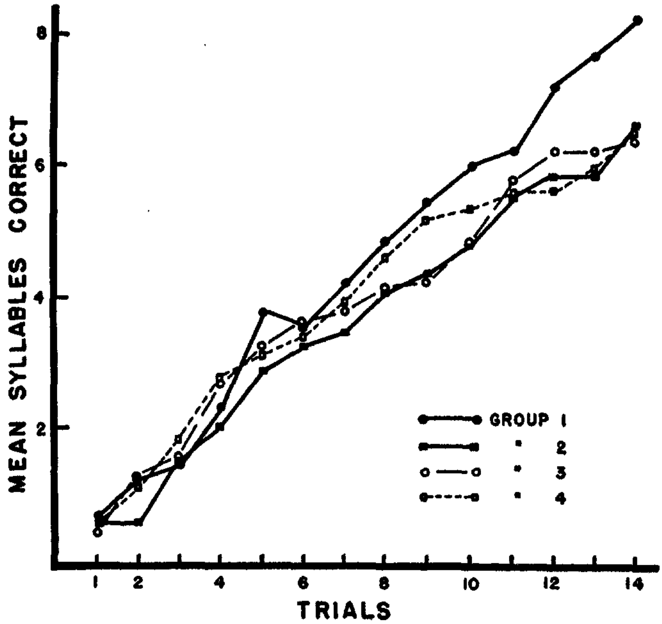

FIG. 2. Learning curves for each of the four groups of the experiment, plotted in terms of average number of syllables correct on each of fourteen trials. Group 1: similar forms presented together; Group 2: similar forms given maximum separation; Group 3: sub-groups of dissimilar forms presented together; Group 4: random presentation.

On trial 12, none of the differences between mean values for Group 1 and the other groups are significant.[2] On trial 13, differences significant at the 5 percent level or better appear between the mean values of Group 1 and Groups 2 and 4, and on trial 14, between the mean values of Group 1 and Groups 3 and 4. If the scores for Groups 2, 3, and 4 are averaged together (since there are no significant differences between them), the following CR's are found for the differences between these means and those of Group 1 on trials 13 and 14: 1.69, 1.97. Differences of this sort in favor of Group 1 would be expected to occur by chance with probabilities of 4.6 percent and 2.4 percent, respectively. The significance of these differences on the last two trials of learning seems reasonably well established by these data.

Occurrence of overt errors.—The average number of overt errors, with standard deviations, on each of 14 learning trials for the four groups of the experiment, is presented in Table II. These values are plotted by averaging successive sets of three trials (using trials 13 and 14 as the final set) in Fig. 3.

The average overt errors of Group 1 rise to an early maximum and then progressively decline. In contrast, the errors of each of the other groups show a more gradual increase during the early stages of learning, and subsequently, at least in the case of

[2] Tests of significance for syllables correct involved the use of a formula for the standard error of means of groups correlated with a matching criterion. The correlation coefficients between score on trial 4 of the preliminary learning task and trial 14 of the experimental task were as follows: Group 1, .38; Group 2, .84; Group 3, .60; Group 4, .82.

Groups 2 and 3, a gradual decline. But the sharp decline of errors in Group 1 following trial 9 is striking in comparison with that of the other groups.

From these data, then, it appears that the procedure of presenting the most similar forms close together in sequence has brought about an increase in generalization during the beginning stages of learning followed by a marked reduction as learning proceeds. On the other hand, in those groups in which the sequences of presentation involved separation of highly similar items, the amount of generalization appears to increase more slowly, and to decrease gradually during 14 learning trials. It might be expected that the increase in overt errors would be slowest of all in the condition of Group 2, in which similar items were presented with maximal isolation, but the data do not support this expectation. As a possible explanation, it may be pointed out that the condition of random presentation is not too different from that of maximal separation, in the sense that probability favors the separation of similar forms by at least one dissimilar form. However, random presentation turns out to be considerably different from the sequence employed with Group 1, since the probability of three forms falling together in sequence, even on a single trial, is rather slight. In view of this, it is perhaps not too surprising that the errors of Group 2 do not differ markedly from those of Group 4. The data of Group 3 for number of errors are also close to those of Groups 2 and 4. This bears out the indication given by the learning scores, that the factor of grouping as such does not play a significant part in determining the results obtained with Group 1.

The points of maximum mean errors which appear in Fig. 3 for Group 1 on trials 4–6, and for Group 2 on trials 7–9 are not significantly different from the values in the other groups. However, the marked reduction in the

TABLE II

Means and SD's of Number of Overt Errors on Each of 14 Learning Trials for the Four Groups of the Experiment

Group 1, similar forms presented together; Group 2, similar forms given maximum separation; Group 3, sub-groups of dissimilar forms presented together; Group 4, random presentation. N = 15 for each group.

Trial	Group 1		Group 2		Group 3		Group 4	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	2.27	1.48	1.87	2.15	2.73	2.75	2.00	1.97
2	3.87	1.92	2.87	2.65	3.20	3.09	3.13	2.56
3	4.80	1.83	3.13	2.45	4.33	2.78	3.73	2.57
4	4.93	1.92	3.20	2.68	4.27	2.74	3.47	2.60
5	4.40	2.44	4.53	2.19	4.53	2.76	4.00	2.03
6	4.73	2.39	3.93	2.70	4.33	2.63	4.13	2.56
7	4.73	1.54	5.33	1.71	4.27	2.40	4.20	2.79
8	4.13	2.28	4.20	1.72	4.43	2.54	3.67	1.84
9	3.67	1.77	4.67	2.35	4.73	2.87	3.67	2.35
10	3.80	2.20	3.80	2.01	4.27	2.54	3.27	2.08
11	2.67	1.44	3.73	2.27	3.53	2.25	3.67	2.02
12	2.47	2.02	3.80	2.04	3.73	2.67	3.73	2.75
13	1.73	1.44	3.60	2.27	3.93	2.96	3.93	3.36
14	1.80	1.38	3.67	2.79	3.93	2.72	3.80	3.10

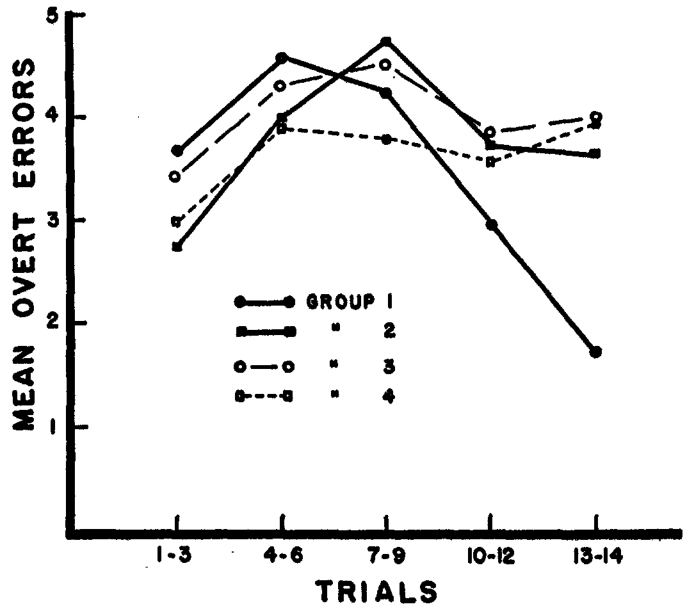

FIG. 3. Average number of overt errors for each of the four experimental groups, on successive three-trial stages. The final point represents the average of trials 13 and 14. Group 1: similar forms presented together; Group 2: similar forms given maximum separation; Group 3: sub-groups of dissimilar forms presented together; Group 4: random presentation.

errors of Group 1 does have statistical significance. On trial 12, the mean values for Groups 1 and 2 are significant at less than the five percent level. For trials 13 and 14, the values for Group 1 differ from those of each of the other groups, as indicated by t's ranging from 2.20 to 2.60. The probabilities of obtaining such error differences in favor of Group 1 by chance range up to two percent. Thus, these data show a significant reduction in overt errors on the final trials of the learning, correlated with the increase in learning score (number of syllables correct) previously described.

The question of the adequacy of the error measure employed needs some discussion. Can number of overt errors be said to be a measure of generalization tendency? Gibson (2) employed a somewhat different measure, namely, number of overt responses indicating confusion with highly *similar* forms. In her study, this measure was clearly distinguished from that provided by number of overt errors indicating confusion with *dissimilar* forms. One of the implications of Gibson's hypothesis is, in fact, that a greater number of similar-type errors should occur than dissimilar-type errors, and this was her experimental finding.

An analysis of type of errors, using the data of the present experiment, shows one result which is in accord with Gibson's hypothesis. This can be seen by comparing the percentages of Type A (similar-type) and Type C (dissimilar-type) errors for each of the four experimental groups, given in Table III. In each case the greater degree of confusion, and according to Gibson's hypothesis, the greater degree of generalization, is with the highly similar forms.

TABLE III

NUMBER AND PERCENT OF THREE TYPES OF OVERT ERROR IN THE FOURTEEN LEARNING TRIALS OF EACH GROUP

Type A, response associated with a highly similar nonsense form; Type B, response associated with none of the forms, but which bore a resemblance to one or more of the actual syllables used; Type C, response associated with a dissimilar nonsense form.

Group	Type A Error		Type B Error		Type C Error		Total Errors	
	N	%	*N*	%	*N*	%	*N*	%
1	222	30	454	60	76	10	752	100
2	243	31	506	64	40	5	789	100
3	163	19	652	77	32	4	847	100
4	172	23	484	64	102	13	758	100

However, the percentage of similar-type errors found in the present study is considerably less than that which Gibson found. The total percentage of similar-type errors reported in her study is 82 percent. In contrast, our data show the greatest proportion of errors to occur in the category labelled Type B, with percentages ranging from 60 percent to 77 percent in the different groups. Type B errors were difficult to interpret. By far the greatest number of them indicated confusion between more than one item of the list. For example, for figure B_1, the correct response was MAF. Similar form B_2 had the associated response POB. The subject said POF. This appears to be a case of a similar-type error, until it is pointed out that a dissimilar form, D_2, had the associated response WOF. It seemed to the author impossible to answer the question as to whether the response POF indicated a confusion of B_1—MAF with B_2—POB or with D_2—WOF. A smaller proportion of B-type errors consisted of responses in which a letter appeared in a position which it had in none of the items of the list. For example, one subject said POM for POB. Again it is conceivable that this response indicates confusion with MAF (since this does contain an 'M'), a response associated with a highly similar form, but it is impossible to say with certainty. For these reasons, it was found impossible to classify Type B errors into categories of similar-type and dissimilar-type confusions.

It is difficult to identify the reason for the difference between our results and those of Gibson with respect to this matter of the percentage of overt similar-type errors. It may be that one should consider the syllables, as well as the forms, as one of the possible sources of confusion (generalization). As a syllable, POB is undoubtedly more like WOF (a response associated with a dissimilar form) than it is like MAF (a response associated with a similar form). The syllables which Gibson used are not reported, and our own data are quite inadequate to test such a hypothesis. At any rate, it must be admitted that *type of error* appears in the present study to be a highly insensitive measure of the direction of generalization tendencies.

One fact about the errors found in the present study is perfectly clear: They all represent confusions of items *within* the list. Not a single clear-cut case was encountered in which an overt error could be said to be entirely 'new,' or different in the sense that it contained as many as two consonants which were not in any of the twelve syllables of the learning list, and only an occasional isolated case of an error containing even one such consonant. Pronounceable consonants not included in the syllables of the list were G, L, N, R, S, X, and Z. (Diphthongs might also be considered to fall in this category.)

On the basis of this evidence, it may be said that number of overt errors, regardless of type, is a good measure of *intra-list confusion.* To phrase this in another way, one may define *generalization* as the tendency of a given stimulus to evoke a response primarily associated with a second stimulus from which the first must be differentiated. The degree to which such differentiation has up to a given time failed to occur is, of course, the degree of intra-list confusion, and is measured by the number of overt errors. This is the sense in which the term generalization has been used in describing our findings with regard to the occurrence of overt errors. Although Gibson employs a different measure, the two are not basically in conflict. In the author's judgment, the present results provide additional evidence in support of the hypothesis Gibson has advanced.

Discussion

The data of this experiment indicate that a method of presentation of paired associates which emphasizes intra-list similarities by having the most similar items appear together in sequence results in more rapid learning of the total set of material than does a method of presentation which emphasizes sequential separation of similar items. When the closely similar items are grouped together, a high degree of confusion, exhibited by the occurrence of a large number of overt errors, takes place toward the beginning of learning. This is followed by a period of rapid reduction in the number of errors as learning continues. In contrast, when the highly similar items are separated in sequence by dissimilar items, the number of overt errors increases more slowly, and decreases more slowly after reaching a maximum, as learning proceeds.

As a first step in interpreting these results, it may be suggested that the presentation of items in similar groups somehow leads to the making of a greater number of overt responses during the early stages of learning. Many of these responses are wrong, though a considerable number are correct. (Examination of Figs. 2 and 3 will show that Group 1 made as many correct responses, and many more incorrect ones, on trials 1–6 than did any of the other groups.) The fact that they are *overt*, however, means that the differential reinforcement provided by the subject's knowledge that they are right or wrong can be most effectively applied. Consequently, the learning of the required discriminations proceeds more rapidly than it does in the groups which made fewer overt responses. Those who like to emphasize the importance of active responding for the process of learning can find support for their views in these results.

Why does the presentation of similar items in groups encourage the making of a greater number of overt responses, correct and incorrect, than does presentation of similar items separated in sequence by dissimilar ones? The present experiment does not present evidence to answer this question. One speculation might run somewhat as follows: The subject first encounters the stimulus form A and makes the correct response to it. Either next, or at some later time, he sees the similar form A_1, which tends also, because of the mechanism of generalization, to evoke this same response. However, the subject overcomes this relatively strong generalization tendency when he gives the correct response (which he sees before him) for stimulus A_1. Thus the process of differentiation begins. When A_1 is encountered immediately after A rather than at some later time, it may be that the immediate neural effects of A (i.e., the stimulus trace: *cf.* 10, 6) arouse stronger response tendencies than would be the case if a longer time were permitted to elapse between the appearance of A and the appearance of A_1. If such were the case, one would expect stronger correct response tendencies and also stronger generalized (incorrect) response tendencies to be engendered when A_1 followed A immediately.

The author has few illusions concerning the possibility of testing such a conjecture with the method of paired associate learning in human subjects. It does, however, suggest one kind of experimental question which might be investigated at this level: Are the results of the present experiment which favor grouped presentation of highly similar forms attributable to differences in separation in the sense of *intervals of time* (*cf.* previous paragraph), or to separation in the sense of *intervening dissimilar items?* An experiment conducted to answer this question would, of course, have to be designed so as to control the well-known effects of rate of presentation on learning (8).

It may be quite possible to conceive of the results of the present experiment in terms of the concept of 'isolation,' though the author does not believe that such an idea has the predictive efficiency of the Gibson hypotheses. At first glance, it would seem that the present data indicate an unfavorable effect upon learning of a condition stressing isolation (Group 2) as compared to one in which non-isolation or 'crowding' (Group 1) is present. But it may be that we are changing the original meaning of isolation, when we try to apply it in this way. As von Restorff used the term, it was supposed to account for the fact that a *single* item was learned more readily if surrounded by dissimilar items than by similar items. In the case of the present results, though, we are asking whether an item (or items) *plus* all the surrounding items are as a whole learned faster in one sequence than in another. The item A_1 might very well be learned more rapidly when surrounded by B and D_2, than when embedded between A and A_2. But what about the total learning of A_1, plus A, plus A_2? When similar forms such as these occur together, it is possible to conceive of the whole group as being isolated, since it is surrounded by groups which are dissimilar. This could account for the ease of distinguishing one group from another, but by itself it seems not to have a clear application to the problem of learning to distinguish the forms *within* each group. It may be noted that Gibson's hypotheses predict both kinds of discrimination equally well.

To turn finally to the related practical learning problem previously outlined: The results of this experiment give a fairly unequivocal answer to the question of arrangement of material in the learning of such skills as aircraft recognition and code reception. Presenting the material in groups of highly similar items, and giving emphasis to the distinctions between them, would appear to be a more efficient procedure than presenting similar items separated by dissimilar ones. The initial confusions of the subjects may be much more evident with the former procedure, but according to the present results, this is an indication of more active learning, which will lead more rapidly to proficiency in the required skill.

Summary

An experiment was conducted to determine the effect of sequence of presentation on the learning of 12 nonsense form-nonsense syllable paired associates, containing four dissimilar sets of three highly similar forms. Four different sequences were employed. In the first, the most similar forms were always presented together in sequence. In a second, each similar form was given the maximum separation by dissimilar forms. A third condition tested the effect of 'grouping' by the presentation of four sub-groups of three dissimilar forms, the members of each sub-group always appearing together in sequence. A fourth condition utilized a pre-determined random sequence of presentation. Four matched groups, each containing 15 subjects, learned the 12 items, one group under each of the conditions. Fourteen learning trials were given. Measurement was made in terms of number of syllables correct on each trial, and in terms of number and type of overt errors. The results may be summarized as follows:

1. Significant differences on the final two trials of learning, in terms of number of syllables correct, indicate more rapid learning for the group to which the items were presented with highly similar forms together in sequence. No differences were found between the scores of the control group and those of the group to which the items had been presented with maximum separation of similar components. Likewise, no effects of grouping, as such, were discovered.

2. In the case of overt errors, again the only significant difference found was in the striking reduction occurring on the final three learning trials in the group to which similar forms were presented together. The overt errors of this group appear to rise to an early maximum and to decline rapidly. When similar items are given separation by dissimilar ones, as in the other three groups, the rise and decline in number of overt errors are more gradual.

3. A greater percentage of errors to similar forms occurred than of errors to dissimilar ones, in all groups. The greatest proportion of errors in each group, however, was of a 'mixed' type, indicating confusion between more than one item *within* the list. Number of overt errors is conceived as a measure of generalization, in the sense that it indicates the degree of lack of differentiation between items to be discriminated.

4. The results are discussed in relation to the hypothesis of intra-list generalization proposed by Gibson (1) and to the concept of isolation employed by von Restorff (11).

5. Practical implications for training in such skills as aircraft recognition and code reception are discussed. The experiment gives evidence in favor of a method of presentation in which groups of highly similar items are given together.

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