

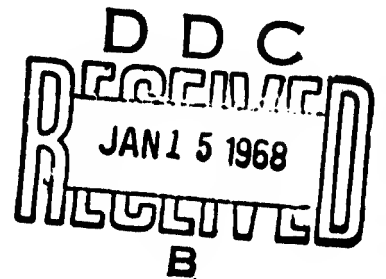
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PAIRED-ASSOCIATES LEARNING UNDER
VARIATIONS IN OCCURRENCES OF RESPONSE MEMBERS

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(Year or Years of Employment in Parentheses)

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PAIRED-ASSOCIATES LEARNING UNDER
VARIATIONS IN OCCURRENCES OF RESPONSE MEMBERS

Albert E. Goss

Most of the experiments on phenomena of paired-associates (PA) learning under variations in occurrences of response members that were undertaken under Contract Nonr 3357(3) continue those executed under Contract Nonr 2691(00). These experiments and some additional experiments are described. Begun under Contract Nonr 3357(3) were several primarily normative assessments of sets of verbal stimuli. Finally, several items that typically combine orientation, review of data and theory, and new theory (orientation-review-theory) were completed, were initiated and completed, or have been initiated but not yet completed.

Experiments

Among the experiments that continue those undertaken under Contract Nonr 2691(00), one group represent a phasing out of the program on acquisition and post-acquisition performance as a function of percentage of occurrence of stimuli (response members, %ORM; stimulus members, %OSM) in combination with variables of stimulus characteristics and relationships between and among stimuli. Another group of experiments represents both continuation and elaboration of the program on acquisition and post-acquisition phenomena with divergent PA units.

Several additional experiments are not immediately on effects of variations in occurrences of stimuli. However, these experiments are of interest per se, and some are desirable antecedents to experiments in which occurrences of stimuli would be varied.

%ORM, %OSM, Stimulus Characteristics, Relationships Between and Among Stimuli

Described in the Final Scientific Report on Contract Nonr 2691(00) (Goss, 1962) were eight experiments on acquisition and post-acquisition performance as functions of %ORM in combination with two or more other variables from among similarity among stimulus and among response members, meaningfulness (M) of stimulus and of response members, and familiarization of stimulus and of response members. The first five of those experiments were reported in Goss, Nodine, Gregory, Taub and Kennedy (1962). The remaining three experiments were reported in Goss and Nodine (1965) as Experiments 1, 2, and 3.

In the final Scientific Report on Contract Nonr 2691(00) it was stated that:

"No further research in the manner of these eight experiments is contemplated. These experiments were conceived as binary-value, parametric assessments of effects of %ORM on acquisition and/or post-acquisition performance and retention under 10% ORM for various combinations of M, similarity, and familiarization of stimulus and of response members. The objective has been substantially achieved" (Goss, 1962, p. 14).

The three additional experiments involving %ORM that were undertaken under Contract Nonr 3357 (3) represent extensions of this variable beyond its role in the previous experiments. Two of these experiments involve extension to include %OSM. The other involves extension to the variables of initial associative strength (IAS) and pattern of IAS with young children as ss.

%ORM,%OSM. The first of the experiments in which %OSM was added involves the variables of %ORM and %OSM combined with those of M of stimulus and of response members. Variations in %ORM and %OSM were achieved by use of three conditions: 100% occurrence of stimulus and response members (100% OSRM); 100% occurrence of stimulus members and 25% occurrence of response members (25% ORM); and 25% occurrence of stimulus members and 100% occurrence of response members (25% OSM). M of stimulus and of

response members was varied in a mixed list in which one pair of CVCs represented each of the four combinations of high or low values of these variables.

Presentation of the members of pairs was at a 2:2-sec. rate. However, when response members were omitted a blank was present for 2 sec. When stimulus members were omitted a blank was present for 2 sec., and then the response member alone was present for 2 sec. Acquisition was carried to a criterion of one perfect trial plus four trials or for 32 trials. There were 10 SS in each of the three percentage conditions.

Acquisition was analyzed in terms of number of trials through the first trial on which the first correct response occurred for each combination of M of stimulus and of response members, and number of trials to criterion for the entire list. For the former measure, significant Fs were obtained for percentages, for M of stimulus members, and for the interaction of these two variables. Acquisition was most rapid under 100% ORSM and least rapid under 25% OSM. Acquisition was more rapid with stimulus members of high than of low M. The size of this difference increased sufficiently in the order 100% OSRM, 25% ORM and 25% OSM to produce the interaction of the two variables.

M of response members did not have a significant effect either overall or in interaction with one or more of the other variables. But the differences obtained were consistent with prior findings or expectations based on such findings. Across the other variables, acquisition was more rapid with response members of high than of low M. This over-all relationship held for 100% OSRM and 25% ORM, but the opposite relationship held for 25% OSM.

Trials to criterion for the entire list decreased in the order 25% OSM, 25% ORM and 100% OSRM. Effects of 25% ORM and 25% OSM did not prove symmetrical, with the latter producing the greater decrement in rate of acquisition.

Details of this experiment can be found in Goss and Nodine (1965); it is Experiment 12.

The second experiment on %ORM and %OSM replicated the first experiment and extended it by addition of another variable, whether or not integration-availability of stimulus and response members of the pairs was assessed. In the second experiment, the 100% OSRM, 25% ORM and 25% OSM conditions without assessment replicate the first experiment.

These percentage conditions were also combined with assessment of integration-availability of stimulus and of response members. Such assessment occurred on each trial immediately following presentation of the pairs. Recall of stimulus members and then of response members, or the converse, was paced by clicks of the shutter of a memory drum at a 2-sec. rate. As previously, for acquisition presentation was at a 2:2-sec. rate, with 2 sec. with stimulus members alone when response members were omitted. Also as previously, the criterion was one perfect trial plus four trials or 32 trials. Ten Ss served in each of the six combinations of percentage conditions and assessment-nonassessment of integration-availability.

For comparisons of acquisition under both assessed and nonassessed conditions, trials to the first occurrence of a response member as a correct anticipation and also as a response per se were determined for each combination of M. For acquisition under the assessed condition alone, trials of the first recall of each stimulus member and of each response member were also determined. Disregarding other variables, acquisition was successively faster under 25% OSM, 25% ORM, and 100% OSRM. With a few exceptions, the same order obtained at each level and combination of levels of M of stimulus members, of M of response members, and of assessment-nonassessment.

Occurrences of responses and anticipations combined were about four trials earlier under non-assessment than under assessment. More generally, acquisition was somewhat faster under non-assessment than under assessment both across the other variables and at each level and combination of levels of the other variables. Introduction of free recall of stimulus and of response members seemingly slowed acquisition.

Both M of stimulus members and M of response members were related directly to acquisition rate. However, these variables entered into but three significant interactions with the other variables.

The second experiment has been reported (Cobb, Farrick, Goss, & Gregory, 1964). But it has not yet been submitted for publication.

%ORM, IAS, pattern of IAS with young children. Relatively little is known of the PA learning of young children. Of particular concern here was the PA learning of children below the age of six years. Because of the demonstrated potency of %ORM in the PA learning of adults (mostly college undergraduates), %ORM seemed a reasonable variable to incorporate in initial experiments on PA learning by young children. Others have done so, too. (e.g. Carroll & Penney, 1966; Shapiro, 1965). Two other variables of demonstrated potency in the PA learning of children are IAS between stimulus members and responses to response members as specified by word-association norms and noncompetitive-competitive patterns of pairing based on IAS (Carroll & Penney, Shapiro). Age is another variable of demonstrated general potency. All four variables were incorporated in this experiment.

%ORM was at 50% or 100% for acquisition of lists of eight pairs of words. Half of the pairs represented high IAS; half represented low IAS. Members of the pairs of the former half were in a noncompetitive or competitive pattern of pairings. Members of the pairs of the latter half were in such pairings in "dummy" fashion. Noncompetitive pairing involve each stimulus

paired with a response member that evokes a response that is strongly associated with the stimulus member by word-association norms. Competitive pairing involves each stimulus member among those of the high IAS half paired with a response member that is strongly associated with some other stimulus members of the high IAS half. Details of the construction of these lists are in Shapiro (1965).

Pairs were presented aurally by playback from a tape. The rate approximated 3:3-sec. per pair. Kindergarten-aged children were administered trials to criteria of one perfect trial or of 16 trials under 100% ORM and of one perfect trial or of 32 trials under 50% ORM. Preschool-aged children had the same criteria except for only 16 trials under 50% ORM.

Totals of correct responses through 16 trials were related directly to %ORM, IAS, and age. More correct responses occurred under the noncompetitive pattern than under the competitive pattern of pairing. In general, %ORM did not enter into significant interactions.

These results were similar to those obtained by others (e.g. Carroll & Penney, Shapiro). Of particular interest was the finding that with number of occurrences of response members matched for kindergarten-aged children--who had essentially 16 trials under 100% ORM and 32 trials under 50% ORM --more correct responses still obtained under 100% than under 50% ORM. Although the difference is not significant, it contrasts with most findings with adults as Ss for whom only small and often nonsignificant differences between 50% and 100% ORM has not been investigated as extensively. It may prove an even more potent variable than %ORM.

The findings obtained in these experiments have proved generally consistent with those obtained by other investigators. Thus, conclusions based on results of experiments undertaken under Contract Nonr 2691(00) and 3357(3) can be regarded as reasonable empirical generalizations for PA learning with lists representing a 1:1 pattern of pairing.

Acquisition and Post-Acquisition Phenomena with Divergent PA Units

The experiments described in the preceding section and, more generally, most experiments referred to as PA learning were with what was called the 1:1 pattern of pairing of stimulus members and of response members. Within a particular list, the 1:1 pattern involves n stimulus members, for each of which there is one and only one response member, and that response member differs from all other response members. As developed in detail elsewhere (Goss, 1966a), other patterns of pairing are possible as well as of empirical, theoretical and applicatory importance. Among those additional patterns is the pattern labeled divergent or 1: n . In this pattern each unit consists of a stimulus member accompanied by two or more response members. The response members of one unit differ from those of the other units. Meaning and meaningfulness and hierarchic are other labels for this pattern of pairing and for the resultant pattern of stimulus-response relationships.

The 1: n pattern of pairings is important in at least two ways. First, for each unit it exemplifies arrangements that have come to be called probability learning (Estes, 1964). Second, and more importantly, the 1: n pattern--as suggested by the alternative labels of meaning and meaningfulness and hierarchic--is very likely the most direct arrangement for establishing multiple responses, multiple meanings to stimuli. Certainly, the 1: n pattern is more direct and the resultant stimulus-response relationships more representative of association hierarchies than the arrangement and presumed changes in ratings that have been termed "meaning established by classical conditioning" (Staats & Staats, 1957).

At the time of initiation of research with divergent PA units in 1958, relatively ^{little} previous work with such units had been undertaken and reported. Part of Calkin's (1894, 1896) pioneering experiments on association through the PA situation and, sixty-years later, experiments by

Peterson (1956), Osgood and Anderson (1957), and Wiggins (1957) comprised virtually all of the pertinent work.

Almost simultaneously with the distribution of the second technical report under Contract Nonr 2691(00) by Sugerman and Goss (1959), Voss, Thompson and Keegan (1959) reported the results of a similar experiment with divergent PA units. They referred to the situation as "S-R₁, S-R₂ probability" in analogy with the probability learning situation. Subsequently the contributions of Voss and collaborators (e.g. Popp & Voss, 1965) and the experiments undertaken under Contracts Nonr 2691(00) and 3357(3) constitute the most extensive series of investigations of acquisition and post-acquisition phenomena with divergent PA units that, up to the present, have ^{been} executed and reported.

One of the experiments undertaken under Contract 3357(3) represents a continuation of the initial concern with demonstration of formation, maintenance, generalization and retention of response hierarchies by means of divergent PA units. The further experiments represent elaboration to parametric studies in which meaningfulness and similarity of stimulus and response members are varied. An additional variable ^{is} of some of these experiments %ORM within a 1:2 pattern of pairings.

Formation, maintenance, generalization, and retention. The first of the two experiments reported in Goss and Cobb (1966) was described earlier on pp. 25-27 of the Final Scientific Report on Contract Nonr 2691(00) (Goss, 1962). Its purpose was to investigate formation, maintenance, generalization and retention of response hierarchies as a function of relative percentages of occurrence of alternative response members (RP) of lists of four PA units. For formation or acquisition, RP was at values of 50-50, 60-40, 70-30, 80-20, or 90-10. Maintenance was tested by presentation of the stimulus members under 0% ORM, that is, with response members

omitted, in the context (same, S) of the acquisition apparatus. Generalization was tested by presenting the stimulus members under 0% ORM in booklets that stimulated a word-association situation. Called generalization, this situation represented a change in the context (different, D) of stimuli rather than the more conventional change in stimuli per se. Retention was tested by presenting stimulus members under 0% ORM in S and D contexts both immediately after and 24 hr after formation. Administration of trials in the S and D contexts in S, D or D, S order was an additional variable.

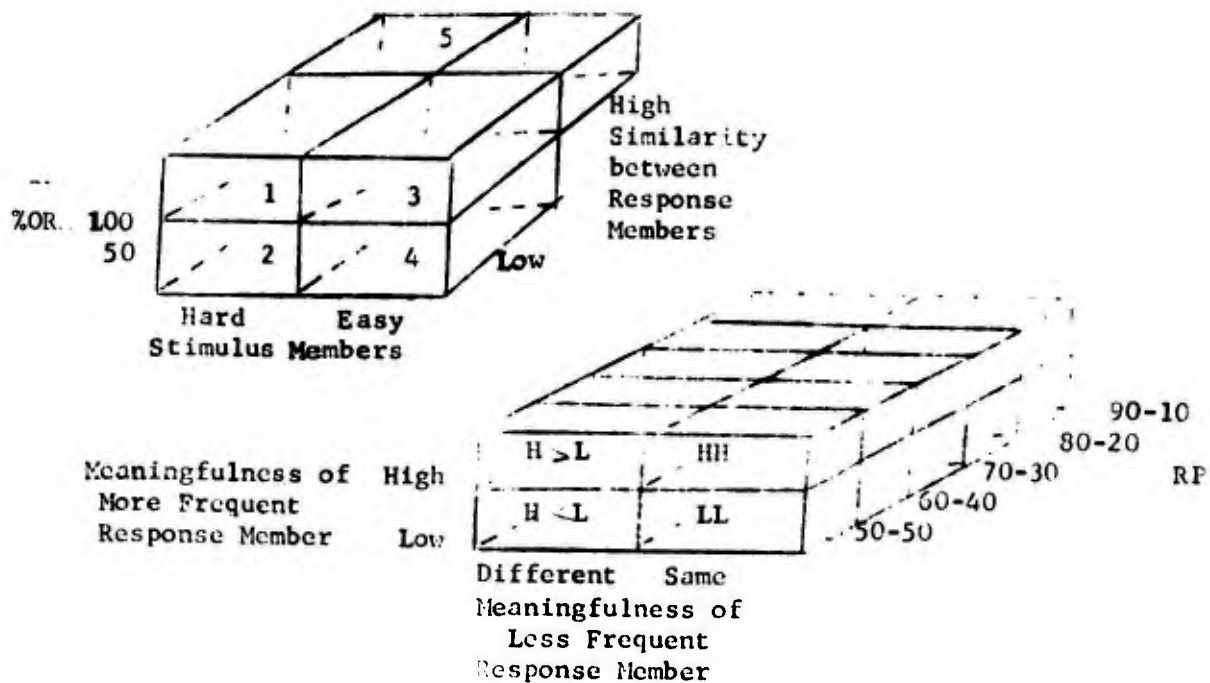
In the next experiment, which was undertaken under Nonr 3357(3), R_1 was at values of 50-50, 60-40, 70-30, or 80-20. The additional variable was whether trials in the S context were with the four stimuli of the divergent units with response members omitted (RMO), with those stimuli alone plus four new stimuli (RMO + St), or with those stimuli alone plus four new divergent units (RMO+DPAU). The latter two conditions were viewed as possibly disruptive of the hierarchies demonstrated previously to be maintained, generalized and retained.

Across units for groups of \underline{S} s, percentage of anticipation of alternative response members was a direct function of actual percentage of occurrence. For RP of 70-30 and above, anticipation of the more frequent response members occurred more often than their actual percentage; and anticipation of the less frequent response members occurred less often than their actual percentage. This outcome was consistent with that of the immediately prior experiment, as well as the outcomes of earlier experiments (Goss, 1965a; Goss & Sugerman, 1961). In addition, the direct relationship between actual percentages of occurrence and recall of response members obtained previously under RMO also obtained under RMO+St and RMO+DPAU. Neither new stimuli nor new divergent PA units altered maintenance, generalization and retention of hierarchies across units for groups of \underline{S} s.

Analysis of protocols for individual Ss indicated formation, maintenance, generalization and retention of hierarchies for individual units or individual Ss.

Meaningfulness and similarity of stimuli, %ORM. In previous experiments, the stimulus and response members of each unit were of low formal and semantic similarity to each other and to members of other units. But variables of M and similarity of stimulus and of response members can be introduced in 1:n and other patterns of pairing. In this series of experiments, these variables in various combinations were combined with RP. In the 1:n pattern of pairings the equivalent of %ORM in a 1:1 pattern is occurrence of the two or more response members of each unit at percentages that sum to less than 100%. Instead of one of two response members on P% of the trials and the other response member on 1-P% of the trials, one response member occurs on P₁% of the trials and the other occurs on P₂% of the trials with P₁% + P₂% < 100%. In the experiments described in the previous section, percentages of occurrence of alternative response members of each unit equaled 100%. Across some of the experiments described here, %ORM with a 1:n pattern, specifically a 1:2 pattern, was an additional variable.

Shown to the top left in the accompanying figure is the manner of manipulation of similarity-meaningfulness of stimulus members (high M, low similarity [easy] low M, high similarity [hard]), similarity between alternative response members of units (low, high), and %ORM.



Each of the four cells of the front slice of this solid incorporates the combinations of conditions shown in the solid to the bottom right. These are RP at values of 50-50 to 80-20 or 90-10 in 10% steps; high or low M of the more frequent response members, except under RP of 50-50; and meaningfulness of less frequent response members the same as or different from that of the more frequent response members. The latter two variables generate combinations of both members of a unit of the same high M (HH), both of the same low M (LL), the more frequent of high M and the less frequent of low M (HL), and the more frequent of low M and the less frequent of high M (LH).

Each of the four cells of the front slice of the figure on the top left represent what was regarded as a separate experiment. Of these four experiments only that for the cell formed of 100% ORM and easy stimulus members has been completed entirely. Each of the other three experiments is essentially the same, except that they involve, successively, cells formed of 50% ORM and easy stimulus members, of 100% ORM and hard stimulus members, and of 50% ORM and hard stimulus members.

The back slice is incomplete both with respect to combinations of M of response members, which are limited to HH and LL; retention interval, which is limited to an immediate test; and %ORM, which is only at 100%. The two cells of this slice had originally been designed as two additional experiments that would differ from experiments of the corresponding cells of the upper front of the figure on the left only in the use of alternative response members of each unit of high formal similarity to each other, but of low formal similarity to response members of the other units. A severe shortage of §§ forced reduction of these two experiments to a single experiment on which only the HH and LL combinations were used and retention was tested only at the immediate interval.

Not shown in these representations of designs is the additional variable of the retention interval which is at values of essentially immediate introduction of trials in S and D contexts or introduction of those trials 24 hr. later.

The results of the first experiment are described in detail elsewhere (Goss & Cobb, 1967). Across units for groups, as previously, percentage of anticipation of response members with those members present and percentage of recall of response members with those members omitted were a direct function of actual percentages of occurrence of response members. The exact form of this relationship was seemingly contingent on meaningfulness of alternative response members of units. For the HL combination the function was steeper than for the HH combination. In turn the function was steeper for the latter combination than for the LL and LH combinations. More specifically, with the HL combination anticipation and recall of the more frequent response members were further above the actual percentages of 60%, 70%, 80% and 90% than was the case for the HH combination, and more so than for the LL and LH combinations. Conversely, with the HL combination, percentages of anticipation and recall of the less frequent response members were further below 40%, 30%^{20%} and 10% than was the case for the HH combination and more so than for the LL and LH combinations. For HH and LL combinations under RP of 50-50, anticipation or recall of response members was below 50%. For the HL, LH combinations together, anticipation and recall of response members were above 50% for response members of high M and below 50% for those of low M.

With the HH combination, as previously, but now for HL, LL and LH combinations, hierarchies formed with response members present were maintained with response members omitted in the S context, were generalized to stimulus members presented alone in the D context, and were retained over 24 hr.

For individual units for Ss individually, hierarchies were formed and maintained with HH combination and also with the HL, LL and LH combinations. As before, the numbers of Ss exhibiting hierarchies for 3 or 4 units decreased as RP changed from 50-50 to 90-10. Also as before, hierarchies were more stable between trials in S and D contexts than between the last 20 trials with response members present and trials in the S or D context.

Upon completion of the analyses of results of the four additional experiments shown in the figure on the left, the outcomes will be presented per se and in comparison with the results of the first experiment. The presentation is expected to be of monograph length.

One more experiment has been completed and submitted for publication. That experiment involves only RP of 50-50 with the HL, LH combination. Goss and Cobb (1967) found percentages of anticipation and recall of response members of high M to be above those for response members of low M during the last 20 of 120 trials with response members present and during trials in S and D contexts with response members omitted. The problem of this further experiment was whether these differences would persist through three further cycles of 20 trials with response members present at RP of 50-50 and of trials in S and D contexts.

Across Ss, the higher percentages of anticipation and recall of response members of high M than of those of low M did hold through the three further cycles. No evidence was obtained of convergence of percentages at slightly below 50% as is characteristic with HH and LL combinations. An analysis of percentages of anticipation and recall for individual units for Ss individually also suggested such persistence.

Conclusions. The data obtained in both the earlier and more recent series of experiments permit conclusions about acquisition and post-acquisition phenomena with divergent PA units; about formation, maintenance, generalization, and retention of hierarchies; and about probability learning. As mentioned earlier, prior to the initiation of the series of experiments under Contracts 2691(00) and 3357(3) and the appearance of experiments within the program of research of Voss and collaborators, almost no data were available on acquisition and post-acquisition phenomena with divergent PA units or units in a 1:n pattern of pairings. In all, five experiments were executed under Nonr 2691(00), all of which have been published (Goss 1965a, 1966a; Goss & Cobb, 1966, Experiment I; Goss & Sugarman, 1961). In all, seven experiments were executed under Contract 3357(3), of which two have been published (Goss & Cobb, 1966, Experiment II; Goss & Cobb, 1967), one has been submitted for publication, and four remain to be analyzed and prepared for publication.

A. PA learning. The results of the two series of experiments indicate that phenomena of PA learning with the 1:n pattern of pairing, at least for units with two response members, are continuous with phenomena obtained with the conventional 1:1 pattern. The same instructions can be used. More importantly, as RP change from 50-50 to 100-0, which is a 1:1 pattern, there is orderly transition in the form of increasing percentages of anticipation and recall of the more frequent response member of a unit. Moreover, M of response member and, on the basis of preliminary examination of the data, similarity between response members of a unit, meaningfulness-similarity of stimulus members, and %ORM for divergent units have effects consistent with expectations based on findings with lists exemplifying the 1:1 pattern of pairing.

B. Response Hierarchies. Response hierarchies are formed, maintained, generalized and, over 24 hr. at least, retained. More specifically, response hierarchies are formed and continue in reasonable correspondence with actual percentages of occurrence of alternative response members. For RP of 70-30 and above with HH and LL combinations of M of response members, and for RP of 60-40 and above with the HL combination, anticipation of the more frequent response members are above and recall/of the less frequent response members are below their actual percentages of occurrence. The exception is some conditions of presentation of a one-unit list.

These results are across units for groups. But hierarchies are formed and maintained for individual units for Ss individually. The particular form of the hierarchies will vary with RP, instructions, M of response members, and possible other variables.

C. Probability learning. Phenomena of probability learning have not been regarded as central to experiments with divergent PA units described here. One reason for this relative lack of concern was findings by Goss and Sugerman (1961) of percentages of anticipation that exceeded actual percentages of occurrence at RP of 70-30 or 80-20 and above for four-unit, one-unit random, and one-unit spaced conditions. They also found that estimates of the growth parameter of the linear model (θ) varied markedly with RP and conditions. Analysis of anticipations during the first 20 trials under RP of 50-50 with the four-unit condition suggested that data cited by Estes (1960) as evidence of all-or-none formation of associations might be due entirely or primarily to differences in initial strengths of associations. Neither the linear model of probability learning nor various among all-or-none models could reasonably account for the findings of this experiment.

In a later experiment (Goss, 1966b) in which only a single PA unit was presented and pairing and test trials were separated, the data indicated

that Ss matched patterns of occurrence of response members. As RP changed from 50-50 such matching increased. These results pose further problems for current models of probability learning.

Additional Experiments

The first of the additional experiments was simply exact replication of one of the experiments carried out under Contract Nonr 2691(00). Another was conceived as the first step of a program of research that would involve first parallel acquisition and then cross-situational transfer with and between 1:1 PA and serial anticipation (SA) situations. Two other experiments represent continuation of prior research on the role of verbal mediating responses in conceptual sorting. A fifth experiment was on respons-mediated dissimilarity among tonal stimuli.

Replication. One of the experiments carried out under Contract Nonr 2691(00) compared acquisition of lists representing combinations of stimulus and response members of high or low M under anticipation and recall formats of presentation. The original experiment was reported as Experiment 7 in Goss and Nodine; the replication was reported as Experiment 11.

PA and SA learning. The same stimuli can be presented as a PA list in a 1:1 pattern or as a SA list within which members of each pair of the PA list are sequentially contiguous. Acquisition of responses within these two situations can be compared. Also, direction and extent of transfer from acquisition with one situation to acquisition with the other situation can be compared.

In this initial experiment, the interest was comparison of acquisition of a list presented as a PA situation and as a SA situation. The design called for six conditions and seven groups of 16 Ss each. Two conditions were eight CVCs of intermediate M presented as a SA list at rates of 2 sec. (SA-2) or 4 sec. (SA-4) per CVC. A third condition was a

dual-function PA list in which each of the eight CVCs of the SA list served both as a stimulus member and as a response member. Presentation of these PA units was in a fixed order in which the response member of pair n was the stimulus member of pair $n+1$ (continuous serial, dual-function PA [CSPA]). The fourth condition was presentation of the same list. But the unit in which a particular CVC was a response member was separated from the unit in which that CVC was a stimulus member (noncontiguous, serial, dual-function PA [NSPA]).

The fifth condition was also with the same list. But the pairs were presented in a different random order on each trial (variable, dual-function PA [VPA]). The sixth condition was presentation of half of the pairs from the preceding PA lists alone with four additional, different PA units in the conventional PA manner. Two lists were required, one for each half of the preceding PA lists. They are designated PA-1 and PA-2. The PA lists were presented at a 2:2 sec. rate.

Acquisition was carried to a criterion of one perfect trial. Means of trials to criterion increased in the order SA-2 (actual number of trials divided by two to equate time) SA-4, CSPA, PA-1, PA-2, NSPA and VPA. The first two, the middle three, the sixth and the last of these conditions-groups were separated from each other. Among factors distinguished as possibly responsible for these differences were S-determined separation or E-determined separation of stimulus and response functions of stimuli, temporal contiguity of occurrence of a stimulus as a stimulus member or as a response member, and constant or random separation.

This experiment has not been submitted for publication. The original intention was to carry out several additional experiments and then to publish them as a monograph. Up to the present, none of the additional experiments has been undertaken.

Concept formation. The two experiments on concept formation continued prior research on the role of verbal mediating responses in concept formation in general and in conceptual sorting in particular. In both experiments the stimuli were 16 blocks that represent combinations of square-circular, large-small, tall-short, black-white. The E-supplied responses of the first task were CVCs. The second task required sorting to match. One variable of the first experiment was the pattern of relationships between the blocks and CVC responses. The CVCs were assigned to blocks on the basis of height-size in a fixed or variable pattern. In addition, no CVC responses were supplied. Instead, Ss looked at and responded to the blocks on the basis of pre-experimentally acquired responses (NTR). The other variable involved instructions to make up to two pre-experimentally acquired responses for "characteristics" of each block. These responses were to be made overtly (overt), covertly (covert), or there was no such requirement (regular).

Acquisition of CVC responses in terms of height-size was carried to a criterion of one perfect trial. Numbers of trials under the variable pattern and under the NTR condition were yoked to those under the fixed pattern. Attainment of criterion or completion of the specified number of trials was followed by four trials of motor sorting. No sorting response was reinforced. Prior to each sorting response, Ss gave each block a name, also without reinforcement.

The primary interest was block sorting as a function of the two acquisition variables. Following acquisition with the fixed pattern, sorting by height-size was nearly perfect for overt instructions, over 75% for covert instructions, and perfect for regular instructions. Following acquisition with the variable pattern, and experiences under the NTR condition, sorting by height-size was at markedly lower percent-

ages. These results were interpreted as indicating verbal mediation of sorting by height-size. Analyses of relationship between Ss' names for the blocks and their subsequent sorting responses also provided evidence of verbal mediation.

The rationale for, method, and results of this experiment are described in greater detail in Rosen and Goss (1965). The rationale for, method, and results of the second experiment are described in greater detail in Goss and Gregory (1966).

The design of the latter experiment involved the overt, covert or regular instructions employed previously. CVC responses assigned by height-size in the fixed pattern were acquired to 4-7/16, 9-12/16 or 16/16 degrees of mastery. The same instructions with the NTR condition served as a control.

Sorting by height-size was a direct function of degree of mastery. But instructions had no effect either over-all or in interaction with degree of mastery. These results, along with analyses of the relationship between the verbal responses and sorting responses, were regarded as further evidence of verbal mediation of conceptual block sorting.

Response-mediated dissimilarity among tonal stimuli. Apparently without exception, the stimuli of experiments on the acquired distinctiveness of cues or response-mediated dissimilarity between and among stimuli has been with stimuli in the visual modality (Arnoult, 1957; Cantor, 1965; Goss & Greenfeld, 1958). One purpose of this experiment was to extend experimentation on response-mediated dissimilarity to stimuli in the aural modality, specifically to pure tones that varied primarily in frequency. Presentation in the aural modality has the advantage of substantially eliminating the problem of effective receptor orientation toward stimuli or toward critical features of stimuli.

Also largely uninvestigated in previous experiments was the role of instructions with respect to verbal responses during acquisitions of criterion verbal or motor discriminations tasks. Another purpose was to assess effects of ^{such} instructions.

One variable of this experiment was three conditions of verbal pretraining. The first was relevant verbal pretraining. Different CVC responses were acquired to pure tones that differed in frequency. Another was irrelevant pretraining, the control, wherein the CVC responses were acquired to pure tone stimuli that differed in amplitude. The third was hear, discriminate, and name (HDN). The task was for Ss to use pre-experimentally acquired responses to tones that differed in frequency.

The other variable was overt, covert, or regular instructions regarding use of those verbal responses prior to the choices of a discriminative motor task. Acquisition under relevant and irrelevant conditions was to a criterion of 7/8 correct responses on two successive trials within 48 trials. Under the HDN condition consistent responses were acquired to the same criterion.

Under all three instruction conditions acquisition of discriminative motor responses was better following relevant pretraining and HDN pretraining than following irrelevant pretraining. Acquisition was better under covert and regular than under overt instructions. The patterns of these differences was viewed as constituting further support of the notion of response-mediated similarity.

Relationships between verbal responses prior to the motor choices and those choices were also analyzed. The outcome was consistent with the notion that verbal responses influence motor choice.

Normative Assessments

The seven normative assessments described here were all with lists of verbal stimuli to which Ss responded with responses acquired prior to the particular task. Learning phenomena--acquisition, retention and other phenomena--were not investigated. However, one objective, indeed the primary objective of three of the assessments, was to provide information about responses to stimuli that would be useful in the construction of lists and, perhaps, in the selection of some variables for experiments on learning phenomena investigated by means of PA and other situations.

Two of the assessments were with CVC content words and one-to-four-letter function words to which multiple associations were required. In a third assessment, stimuli were used again but repeated rather than presented once and with only one association rather than multiple associations requested on each repetition. In the fourth assessment, Ss wrote sentences in response to some among the CVC content words. A fifth assessment was with nonword CVCs at five different levels of M. Another assessment was with a very large list of words and dissyllables to which various kinds of responses were required. The seventh assessment was with blanks, single and double letters under instructions to fill the blanks to provide CVCs.

CVC, other words and multiple associations.¹ The 52 content words of the list were selected from among CVCs of Noble's (1961) calibration. They had m values from 2.64 to 4.78. Those from 2.74 to 3.31 and from 3.82 to 4.78 were arbitrarily classified as of low or high M, respectively. The remaining 13 words were function words of from one letter (a) to four letters (e.g. some).

1. This assessment was carried out by Sydelle Stone Shapiro who began as a Public Health Service Predoctoral Research Fellow and was then an AAUW-General American Fellow.

In the first assessment these 65 words were administered to boys and girls in Grades 4, 6, and 8. The instructions called for up to five different associations to each stimulus within 18 sec. Protocols of 100 boys and of 100 girls in each grade were analyzed. Results of this analysis have been distributed (Shapiro, 1963).

Among the uses of these norms was construction of lists for experiments of PA learning, one of which is that involving %ORM, IAS, and patterns based on IAS with young children described earlier.

The same list has been administered to college undergraduates in the same way. These protocols have not yet been analyzed completely or used.

CVCs, other words, and repetition. The same list of 65 words has also been divided into five lists of 11 each of those words and a list of 10 plus another word. Each of the 11 words of these sublists was presented 100 times. The objective was to determine patterns of associations through many presentations of stimuli.

Ten undergraduates responded to the words of each sublist. Protocols have been transcribed to punched cards; but they have not been analyzed further formally. Inspection indicates that varied responses, forming frequency hierarchies, constitute the typical pattern of Ss' associations.

CVCs and sentences. Twenty words from among the 65 of Shapiro's lists were selected for presentation to Ss under instructions to imbed their associations in sentences. Data were obtained for reduction to protocols of 150 Ss. Analysis of these data has not been completed. Since more adequate data have been obtained during the past year, it is doubtful that the analysis will be completed.

CVCs at different levels of M. A list of CVCs was prepared with 10 each at Archer association values of 1-6%, 21-25%, 48-52%, 75-79%, and 96-100%. Within each of the subsets of 10 CVCs, none of the members had

more than one letter in common. The entire set of 50 CVCs was arranged in 10 different random orders for Ss to continue responding through these 10 orders. Unfortunately, the task proved too long for most Ss to complete in an hour. In general, the protocols had responses up through 5 or 6 repetitions. Through 5 or 6 repetitions Ss could vary their responses. Useful as a demonstration of such variation, the CVCs are too few in number to provide useful norms.

Words and dissyllables.² In order to provide a more suitable list of stimuli for experiments not only with lists but also with discourse, a list constituted of 568 words and dissyllabic nonwords was prepared. The latter comprised many high frequency content words and most of the more frequent function words of English.

Subsets of 63 or, in one case, 64 of these words were administered to groups of 40 college undergraduates each, half male and half female. The words were presented aurally and then visually, or the converse. In each modality, the first assessment was of recognition of the word. They were presented at a duration of about .07 sec. or at a signal-to-noise ratio of less than 70 db. to about 72 db. All words of a subset were presented in one random order for assessment of recognition. Each was presented again in a different random order. As each occurred, Ss first responded with as many different associations as possible within 20 sec. They then rated the word along seven-point scales defined as familiarity and pronunciability. Finally, they indicated which among seven grammatical functions was most typical for the word.

These protocols are to be analyzed both for individual Ss and across the entire group. The resultant values of M of the words as

2. Carried out in collaboration with Jean Carl Cohen and Barbara S. Musgrave, primary support for this assessment came from a grant-in-aid from the Research Council of the University of Massachusetts.

defined by number of different associations, and of their familiarity and pronounciability, as well as the indication of their grammatical function should permit construction of materials for a wide range of experiments on verbal learning based greater knowledge about more words than heretofore has been the case.

Blanks, single and double letters. In experiments in which CVCs serve as response members it is desirable to know the manner of Ss guessing within information that the response is of CVC form and within various amount and kinds of additional information. To obtain this **knowledge** Ss responded to stimuli constituted of different combinations of blanks and of single and double letters under instruction fill the blanks to provide CVCs. Specifically, the stimuli were three blanks; each of 21 consonants alone in initial and in final positions along with two blanks in the other positions; each of five vowels (a,e,i,o,u) alone in the medial position along with blanks in initial and terminal positions; each of the combinations of two consonants in initial and terminal positions along with one blank in the medial position; each of the combinations of initial consonant and medial vowel along with one blank in the terminal position; and each of the combinations of medial vowel and final consonant vowel along with one blank in the initial position. These stimuli are responded to once in one random order and then again in another random order.

Data on several hundred Ss have been obtained. The plan is to continue until data are available on 1000 Ss. Only with a very large number of Ss is it possible to estimate frequencies of very infrequent completions.

Orientation-Review-Theory

Complementing and extending the experiments and normative assessments are several items that represent mixtures of what might be described as orientation to a particular area of research, review of pertinent prior data and theory, and extension of the theory. These items are called orientation-review-theory. The first is a book. The second and third are a paper that was presented at a meeting of the American Psychological Association then expanded for presentation at a Conference. The fourth and fifth are conceived as articles for the Psychological Bulletin.

Book. Described in the Final Scientific Report on Contract Nonr 2691(00) (Goss, 1962) was a prospective monograph by Goss and Nodine on M, familiarization and similarity in PA learning. With successive revisions the monograph reached book length. At that point it was decided to add a number of experiments that had involved M, familiarization and similarity in various combinations with each other with and without %ORM as an additional variable. The result was the book by Goss and Nodine entitled Paired Associates Learning: The Role of Meaningfulness, Similarity and Meaningfulness.

Published in 1965, the book represented a detailed and comprehensive review of data and theory on effects of meaningfulness, familiarization and similarity on PA learning. In addition, techniques of the scaling of meaningfulness and of similarity were described along with results of such scalings. The 12 experiments that were included as an appendix represent the most extensive data available on M and similarity in PA learning. Considerable information about %ORM and other variables is also presented. Eleven of the 12 experiments were executed under Contracts Nonr 2691(00) and 3357(3), nine under the former contract and two under the latter contract.

Conference presentation. Research on PA learning is often criticized as being too far removed from materials and phenomena of verbal learning outside of the laboratory. In partial answer to this criticism of research on PA learning, a paper was prepared for a "Discussion" of PA learning at the 1965 meeting of the American Psychology Association in Chicago. Entitled "Paired Associates and Knowledge" (Goss, 1965b), the thesis was advanced and elaborated that research on PA learning provided considerable information of pertinence to an understanding of the extra-laboratory acquisition of knowledge in classificatory form.

Later, this paper was expanded for presentation at a "Symposium on Verbal Learning Research and the Technology of Written Instruction" sponsored by the Office of Naval Research through the Bell Telephone Laboratories and Teachers College of Columbia University. Now entitled "Paired Associates and Connected Discourse in the Acquisition of Knowledge" (Goss, 1966b) this paper had four objectives. The first was specification of the general nature of scientific and systematic knowledge, with emphasis on conventional written formats of presentation of such knowledge. The second was to specify similarities and differences in structures of PA and connected discourse situations. The third was to expand the domain of application of concepts and principles of verbal learning discovered and organized by means of laboratory situations. The fourth was demonstration of the pertinence for understanding the acquisition of knowledge of concepts and principles discovered and organized by S-R psychologists. This paper is to be published as part of the book that reports the conference.

Psychological Bulletin. In preparation with Calvin F. Nodine as the senior author is a presentation of paradigms of, data on and theory regarding temporal variables in PA learning. The intention is to submit this article to the Psychological Bulletin as a possible monograph supplement.

Also in preparation is a review of paradigms of and data on effects of variations in occurrence of stimulus members and response members of PA lists in 1:1 and 1:n patterns of pairing. Upon completion of this article, the intention is to submit it to the Psychological Bulletin. It should be a useful review of research undertaken under Contracts 2691(00) and 3357(3), as well as of research by others.

Summary

Our primary concern were various experiments. In addition, several normative assessments were undertaken as well as several items called orientation-review-theory.

Experiments. Experiments carried out under Contract Nonr 3357(3) were divided into those that extended research done under Contract Nonr 2691(00) on %ORM and stimulus characteristics and those that continued and extended research done under the previous contract on acquisition and post-acquisition phenomena with divergent PA units. Two of the three experiments of the former group were with %ORM in combination with %OSM and M of stimulus and of response members. The third experiment was with %ORM in combination with IAS, pattern of IAS, and age of young children.

One of the seven experiments with divergent PA units was with RP in combination with nature of change during trials in the S context and with retention interval. Five of the remaining experiments were with RP in combination with various subsets of variables from among M of response members, similarity between alternative response members of a unit, M-similarity of stimulus members, %ORM, and retention interval. The seventh experiment was with alternative response members of a unit of high or low M under RP of 50-50 through four cycles of 120 trials with response members present and trials in S and D contexts.

The first of five additional experiments was replication of an experiment carried out under Nonr 2691(00) on acquisition of lists representing combinations of high or low M of stimulus members and of response members under anticipation and recall formats. A second experiment was concerned with parallel acquisition of a list in PA and SA form. Two additional experiments were concerned with the role of verbal mediating response in conceptual sorting. The variables of the first of these experiments were patterns of pairings between block stimuli and CVC response and instructions regarding verbalization of pre-experimentally acquired names during acquisition of the CVCs. The variables of the second experiment were degree of mastery of the relationships between blocks and CVC responses, and instructions. The fifth experiment was concerned with response-mediated dissimilarity among tonal stimuli as a function of type of verbal pretraining and of instructions regarding verbalization of names for the stimuli during the criterion motor discrimination task.

Normative assessments. The normative assessments were of interest per se and some were also to obtain information about Ss response to words and parts of verbal stimuli that would be of use in construction of lists and discourse and in specifying initial states of response hierarchies. Two of the assessments were with CVCs and some ^{one-to} four-letter function words to which multiple associations were obtained. The first was with children in Grades 4, 6, and 8. The second was with college undergraduates. ^{In a third assessment} the same words were each presented 100 times with single associations required in order to determine the nature of hierarchies to individual words for individual Ss. In the fourth assessment a subset of 20 of these words was administered for Ss to incorporate them in sentences. The fifth assessment was of associations to repetitions of **CVCs** at five levels of M.

A sixth assessment was with a list of 568 words and nonword dissyllables. Recognition responses, multiple associations, ratings of familiarity and pronounciability and specification of grammatical function were obtained. The seventh assessment was concerned with responses to blank and letters under instruction to fill the blanks to produce CVCs.

Orientation-Review-Theory. The major item among those called orientation-review-theory was the book on PA learning by Goss and Nodine (1965). Reported in the appendix of this book were 12 experiments, nine of which had been carried out under Contract Nonr 2691(00) and two of which were carried out under Contract Nonr 3357(3).

In addition, papers were prepared and presented on "Paired-Associates and Knowledge" and on "Paired Associates and Connected Discourse in the Acquisition of Knowledge." In preparation is a paper with Nodine on temporal variables in paired-associates learning and another on effects of stimulus occurrence in PA learning.

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- a. Begun and completed under Contract Nonr 2691(00).
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d. As in c, but not mentioned in text.

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13 ABSTRACT
Experiments, normative assessments, and orientation-review-theory on or preparatory to acquisition and post-acquisition phenomena with conventional and divergent paired-associates (PA) situations are summarized. The variables of particular concern are variations in occurrences of response members, specifically percentage of occurrence with the conventional PA situation and relative percentage of occurrence with the divergent PA situation. Among the additional variables of one or more experiments are the stimulus characteristics of meaningfulness and similarity, and initial strength and derived patterns of relationships between stimulus and response members. The normative assessments with a variety of verbal stimuli are designed to provide data that permit more precise and more complete specification of initial reactions to members of PA units both discretely and in relation to each other. On occasion, these experiments and assessments, along with such contributions by others, are summarized, evaluated, and extended in the items labeled orientation-review-theory.

16. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Paired-associates (learning) Percentage of occurrence of response members Relative percentage of occurrence of response members Meaningfulness of stimuli Similarity among stimuli Response hierarchies Probability learning Concept formation Initial associative strength						

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