the number of response-reinforcement and stimulus-reinforcement pairings.

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NUMBER OF ALTERNATIVES AND RATE OF PRESENTATION IN VERBAL DISCRIMINATION LEARNING

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Verbal discrimination lists in which half of the items were two-alternative and half were four-alternative items were presented at either a 3:1-sec. rate or a 7:1-sec. rate. Following learning of the lists, *S*s were given the incorrect alternatives and then recalled the correct alternatives. Learning of four-alternative items was faster than learning of two-alternative items, and items presented at the slower rate were learned faster than items presented at the faster rate. Correct alternatives from two-alternative items and items presented at the slower rate were better recalled and were more strongly associated with the appropriate incorrect alternatives. The results are discussed in terms of a frequency theory of verbal discrimination learning.

Two recent studies have demonstrated no differences in speed of learning two-alternative (2A) and four-alternative (4A) verbal discrimination lists (Radtke, 1968; Radtke & Foxman, 1969). When the data were corrected for differential probabilities of guessing the correct alternative, better learning was found for 4A lists than for 2A lists. Both of these studies employed a constant 3-sec. anticipation interval. This would produce a shorter effective anticipation interval or response time for 4A than for 2A, since it must be assumed that it takes longer to scan and encode 4A items than 2A items. The effect of this difference in response time was in part reflected in the significantly greater number of response omission errors for 4A items than for 2A items. Lengthening the anticipation interval so that *S* would have sufficient time to select one of the alternatives and give his response should benefit 4A items more than 2A items.

The effect of number of alternatives can be interpreted in terms of the frequency theory of verbal discrimination learning proposed by Ekstrand, Wallace, and Underwood (1966). Briefly, frequency theory assumes that *S*s discriminate alternatives on the basis of differences in frequency between the alternatives, with greater frequency accruing to correct alternatives (CAs) than to incorrect alternatives (IAs). Frequency units are produced by scanning and encoding the alternatives during the anticipation interval, pronouncing an alternative, and rehearsing the feedback as to the CA. With a constant, relatively short anticipation interval, fewer frequency units accrue to both CAs and IAs in 4A than in 2A items since there is not as much time to scan and encode the alternatives with 4A items. This would produce a greater relative difference in frequency between CAs and IAs for 4A than for 2A items. For example, if one were to assume a 4-sec. anticipation interval with *S* encoding 1 alternative/sec, two frequency units would be produced for each alternative in 2A items, while one frequency unit would be produced for each alternative in 4A items. With pronunciation of the CA and rehearsal of the feedback, two additional frequency units would be added to the CA. There would then be a 4:2 frequency difference in favor of the CA for 2A items and a 3:1 difference for 4A items. With a greater relative difference in fre-

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quency between CA and IA, discrimination for 4A items should be easier.

According to frequency theory, an increase in the anticipation interval either should not affect learning or perhaps even have an inhibitory effect. When the anticipation interval is lengthened, additional opportunities are provided for scanning and encoding the alternatives. If there were increased study of the alternatives during the anticipation interval, frequency for both CAs and IAs would increase, producing a smaller relative frequency difference between CAs and IAs. In this way, discriminability between CA and IA would be reduced and performance would be hindered. Unless *S* were to spend differential amounts of time on 4A and 2A items, the inhibitory effect of lengthening the anticipation interval would be the same for both types of items. Thus, according to frequency theory, the effect of lengthening the anticipation interval depends on whether *S* increases his study of the alternatives. Aside from increased response time, however, no facilitating effect of lengthening the anticipation interval would be predicted.

The present study was designed to determine the effects of varying the length of the anticipation interval on the learning of 2A and 4A items.

Method.—The basic design consisted of two levels of number of alternatives manipulated within *S*s and two rates of presentation varied between *S*s.

All lists were constructed from four-letter A and AA Thorndike-Lorge (1944) words. Two 16-item lists were constructed with different words, each list consisting of eight 2A items and eight 4A items. The two lists served as two replications of the basic design. The lists were presented on a memory drum at two different rates, a 3 : 1 and a 7 : 1-sec. rate, with 4- and 8-sec. intertrial intervals for the two rates, respectively. Since Underwood and Viterna (1951) have shown that intertrial interval has no effect on verbal discrimination learning, the confounding of intertrial interval with presentation rate was not expected to bias the results. A standard anticipation procedure was used, with the first trial a guessing trial. The CA was presented alone behind the shutter for feedback. There were four random orders of each list, with the position of the alternatives in an item counterbalanced across the different orders. Learning was continued for eight trials or to a criterion of three consecutive errorless trials, whichever came later.

Following learning there was a cued recall test for the CA. The *S* was given a paper on which the IAs from the list he had just learned were printed. For 4A items, the three IAs were presented together as a cue for recall. The *S* was instructed to write next to the appropriate IAs all the CAs he could remember. If there were CAs *S* recalled but was not able to associate with an IA, he was to write them at the bottom of the page. Unlimited time was given for recall of the 16 CAs.

TABLE 1

TOTAL ERRORS, TRIAL OF LAST ERROR PER ITEM, NUMBER OF ALTERNATIVES RECALLED, AND PROPORTION OF RECALLED ALTERNATIVES CORRECTLY ASSOCIATED

Rate	Total errors	Trial of last error	Recall	Association
2A				
4 sec.	9.55	2.38	5.35	.83
8 sec.	5.45	.91	6.45	.96
M	7.50	1.64	5.90	.90
4A				
4 sec.	6.30	1.56	4.60	.42
8 sec.	4.20	.84	5.70	.77
M	5.25	1.20	5.15	.61

Forty introductory psychology students served as *S*s and were randomly assigned to the four Replication Lists × Presentation Rate conditions.

Results and discussion.—The analyses revealed a significant list effect, with one list learned faster and recalled better than the other. However, lists did not interact with number of alternatives or presentation rate, and the data presented is collapsed over the two lists.

Acquisition performance was analyzed both in terms of number of errors from Trial 2 to criterion and average trial of the last error per item. These data are presented in Columns 2 and 3 of Table 1. The analyses revealed essentially the same results. As is apparent, fewer errors and faster learning occurred on 4A items than on 2A items, $p < .005$. Presentation rate, with fewer errors and faster learning occurring at the 7 : 1-sec. rate, was also significant, $p < .025$. However, the apparent interaction, with greater improvement with the slower rate on 2A than on 4A items, was not significant.

The better performance on 4A than on 2A items supports the frequency theory derivation based on the greater relative difference in frequency between CA and IA for 4A items. This finding is especially noteworthy since there was a greater chance probability of making an error on 4A than on 2A items. The first trial, which was a guessing trial, had a mean of 5.9 and 3.9 errors for 4A and 2A items, respectively, which is very close to the a priori expected probabilities of .50 and .75. In the previous studies (Radtke, 1968; Radtke & Foxman, 1969) in which number of alternatives was varied between *S*s, there were no significant differences between 2A and 4A items in number of errors, the small difference being in the direction of more errors on 4A items. It was only when correction was made for the differential probabilities of guessing the CA that performance on 4A items was significantly better than on 2A items. In the present study, with number of alternatives varied within *S*s, the correction for differential guessing was not necessary to demonstrate superior performance on 4A items.

The reason for the relatively better performance on 4A items when number of alternatives was manipulated within *S*s is not entirely clear. A possible reason may involve list length considered in terms of total number of verbal units. In the between-*S* comparisons, 4A lists had more verbal units than 2A lists, while in the present within-*S* comparison, the total number of verbal units within the list was the same for 2A and 4A items. Longer lists may produce increased opportunities for between-item similarity or associative connections which would retard learning (Radtke & Foxman, 1969).

According to frequency theory, learning should have been unaffected or retarded by increasing the length of the anticipation interval. This prediction was based on the potential decrease in relative frequency difference between CAs and IAs as a function of the increased opportunities to study all alternatives with the longer anticipation interval. The results, however, indicated that lengthening the anticipation interval improved performance rather than retarded it. This does not appear to be simply a performance effect due to insufficient response time at the shorter interval. Omission errors were very rare; only 19, or 4%, of all errors were omissions. Furthermore, there was no difference between 2A and 4A items in number of omissions, there being 9 2A and 10 4A omission errors. If lengthening the anticipation interval simply affected performance, more frequent omissions, especially on 4A items, would have been expected. Hence, a learning difference rather than a simple performance difference seems indicated.

The better learning at the slower presentation rate may relate to the total-time hypothesis, which states that the amount learned is a function of study time. Cooper and Pantle (1967) have distinguished between nominal and effective study time. Since the time during which the correct response was displayed was the same for both presentation rates (1 sec.), the nominal study time was the same. Therefore, according to this hypothesis, there must have been some differential effective study time. One possibility is that *S*s rehearsed the previous items during the anticipation interval, especially during the longer interval. In addition to selecting an alternative as a response from the presented item, a portion of the 7-sec. interval may have been spent rehearsing previous CAs. The 3-sec. interval would not have provided as much time for such rehearsal of prior CAs. In this way the longer anticipation interval may have provided more effective study time in which frequency could have accrued to CAs. The apparent greater improvement for 2A than for 4A items presented at the slower rate may indicate a tendency to spend more time rehearsing previous CAs on 2A items. However, the Number of Alternatives × Presentation Rate interaction was not significant.

The mean number of CAs recalled on the cued recall test are presented in Column 4 of Table 1. More CAs from 2A items were recalled than from 4A items, $p < .005$, and more CAs were recalled from the lists presented at the slower rate, $p < .01$. The interaction was not significant. An analysis was also performed on the proportions of all CAs recalled that were associated with the appropriate IA. These data are presented in the last column of Table 1. Analysis of variance of the arcsine transformed proportions indicated that associations between CAs and IAs were more probable for 2A than for 4A items, $p < .001$, and more probable for the slower presentation rate, $p < .005$. The interaction was again not significant.

Any interpretation of the recall data must bear in mind that there were more overlearning trials on 4A items and on items presented at the slower rate. This would be expected to facilitate recall of those items. In spite of the overlearning advantage, recall and association given recall were poorer for 4A items than for 2A items. Since greater frequencies were hypothesized to accrue to 2A CAs, and since frequency should be directly related to recall, the better recall for CAs was in accord with frequency theory. Similarly, since there was less frequent scanning and encoding of the alternatives in 4A items, there were relatively fewer contiguous occurrences of CAs and IAs. Hence, the associations between alternatives were weaker. It should be noted that the associative measure is an inflated index of the degree of association since it is conditional upon recall of the CA. It is undoubtedly true that those CAs which had the strongest associations were more likely to be recalled. Moreover, any interpretation of the recall data in terms of the relatively greater frequency for CAs from 2A items must be tempered by these differential associations which would also produce differential recall.

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