Response word frequency in paired-associates learning[1]

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The influence of normative-response word frequency upon paired-associates performance was studied. An unmixed-list design was employed in contrast to earlier reports which employed mixed-list designs. The results indicated that performance on high response frequency pairs was significantly superior to performance on low response frequency pairs, thus paralleling previous findings with mixed-list designs. The effect is therefore not simply due to priority habits. A replication experiment with unmixed-lists confirmed the results of the earlier experiment.

The frequency of occurrence of words in the English language has been generally found to influence their learnability in several verbal-learning tasks. Frequency of occurrence of words as judged from the Thorndike-Lorge (1944) count has been found to be influential in serial learning (Postman, 1961), free recall (e.g., Bousfield & Cohen, 1955; Hall, 1954), short-term memory (Lloyd, 1964), and paired-associates learning (Jacobs, 1955; Martin, 1964; Postman, 1962; Saltz, 1967; Saltz & Modigliani, 1967). The studies of paired-associates learning indicate that increasing stimulus word frequency does not uniformly improve performance. The effects of increasing response word frequency, however, are more straightforward and indicate that increasing frequency leads to better performance. Only two of the studies have been expressly directed to assessing the influence of Thorndike-Lorge response word frequency on paired-associates performance (Postman, 1962; Saltz & Modigliani, 1967). These two studies have in common the employment of a mixed-list design and, while the results are in agreement, we are lacking a demonstration that increasing response word frequency facilitates paired-associates performance with unmixed-list designs as well. The limitations on generalizing from the results of mixed-list designs have been concisely summarized elsewhere (Underwood, 1966). The present investigation, therefore, was directed to assessing the influence of response word frequency upon paired-associates performance employing an unmixed-list design. Several paired-associates lists were constructed from a set of CVC trigrams which served as stimuli and either high or low Thorndike-Lorge frequency words served as responses.

MATERIALS

Six lists were composed of 10 paired associates each. The 60 response words (10 per list) were selected from the stimuli listed in Shapiro & Palermo (1968). Half of the response words possessed relatively high Thorndike-Lorge (1944) word frequencies in the G count and consisted of AA words (at least 100 occurrences per million) or A words (50-99 occurrences per million words); the other half of the response words ranged from 0-10 occurrences per million words. Ten high-frequency or low-frequency responses were randomly assigned to a list. Thus, there were three unmixed lists of high-frequency responses and three unmixed lists of low-frequency responses. The primary grammatical usage of 56 of the response words was as a noun (Barnhart, 1951). An adjective and a verb appeared on one high- and one low-frequency list. In selecting the response words, interitem free associations were minimized. Two of the low- and high-frequency response lists contained no interitem free associations as judged by the norms listed in Shapiro & Palermo (1968). The remaining high-frequency list contained three idiosyncratic interitem associations and the remaining low-frequency list contained one such association. The same 10 stimulus items were employed for all six lists and consisted of 10 CVC trigrams selected from Archer (1960) and ranging in association value from 71% to 81%. There were two trigrams each with the letters A, E, I, O, and U serving as vowels, and there were no repetitions of consonants within the initial or terminal consonants. Thus, similarity among the trigrams was minimized. The pairings of the CVC trigrams with the responses assigned to a list were random, with the restrictions that the initial letters of the items of a pair could not be identical, nor was a pair with the same terminal trigram letter and initial response word letter allowed.

PROCEDURE

All words were typed in capital letters on memory-drum tapes. The lists were presented at a 2:2:4-sec rate by means of a Lafayette memory drum (Model 303-B3). Each S was run individually. Paired-associates learning was conducted by the anticipation method to a criterion of two successive errorless trials. Any S failing to reach criterion within 32 trials was excluded. To minimize serial-learning effects, four randomized orders of the pairs of each list were employed, with the restriction that no pair appeared in an initial and/or terminal position of an order more than once. Furthermore, an approximately equal number of Ss learning a given list were started on each of the four orders of the list. Assignment to a starting order was random with the restriction that one S was run on each of the four orders before repeating a starting order.

SUBJECTS

The Ss were 120 native English-speaking students enrolled at the University of Hawaii. The Ss were given extra grade points for participation in the experiment. Each of the six lists was learned by 20 different Ss. The Ss were randomly assigned to learn one of the lists with the restriction that an S was run on each of the six lists before reassigning a list. Approximately two-thirds of the Ss learning each list were females and the remainder were males. None of the Ss had served in a prior paired-associates experiment and all but a few were naive to any verbal-learning experiment. An additional 20 Ss were excluded from the experiment, 6 because of apparatus failures or E errors, and 14 Ss who failed to reach criterion (11 on low-frequency lists and 3 on high-frequency lists).

RESULTS AND DISCUSSION

A one-way analysis of variance performed upon the numbers of trials to criterion for the three high response frequency lists yielded a nonsignificant $F = 1.23$, $df = 2/57$. A similar analysis applied to the numbers of trials to criterion data for the three low response frequency lists also yielded a nonsignificant $F = 2.91$, $df = 2/57$. The data, therefore, for the three high response frequency lists (60 Ss) and for the three low response frequency lists (60 Ss) were combined for the ensuing analyses. The mean number of trials to criterion for the high response frequency condition was 13.68 ($SD = 6.68$) and 17.52 ($SD = 7.15$) for the lower response frequency condition. A two-tailed t test indicated that the two groups differed significantly in the number of trials needed to reach criterion [$t(118) = 3.08$, $p < .01$]. The mean error rate for the high response frequency condition was 2.94 ($SD = 0.86$) and 3.43 ($SD = 0.95$) for the low response frequency condition. This difference was also significant as indicated by a two-tail t test [$t(118) = 2.93$, $p < .01$]. It will be recalled that a disproportionately greater number of Ss failed to reach criterion on low than on high response frequency lists (11 vs 3). A test of the significance of this disproportionality yielded a $z = 2.14$, $p < .02$. An implication of this result is that performance differences in the high vs low response frequency conditions were possibly attenuated since replacing disproportionately more Ss in the low response frequency condition biases the selection of Ss in this condition in favor of faster learners.

The results of the experiment therefore clearly indicate that higher response frequency lists lead to better paired-associates performance than low response frequency lists when an unmixed-list design is employed. These results are similar to the previously cited studies of Postman (1962) and Saltz & Modigliani (1967), both of whom employed mixed-list designs. The superiority of high response frequency pairs in paired-associate performance, therefore, is not simply due to a priority habit of selecting pairs with high response word frequencies to be learned first (Underwood, 1966).

REPLICATION EXPERIMENT

Two unmixed lists of 10 paired associates each were composed of responses with either high or low Thorndike-Lorge frequencies. To construct the single high-frequency list, three responses each were randomly selected from two of the previous three high response frequency lists and four words were randomly selected from the third high response frequency list. The low response frequency list was similarly constructed from the three low response frequency lists from the earlier experiment. The same 10 CVC trigrams were again employed as stimuli and were randomly paired with response words subject to the restrictions noted earlier. The procedure was identical to the earlier experiment. The Ss were 40 different native English speakers selected from the same pool. The Ss were alternately assigned to learn one of the two lists so that 20 Ss were tested on each list. The data of one additional S were excluded for failure to reach criterion and of one S for an apparatus malfunction. Approximately one-quarter of the Ss on each list were males and the remainder were females.

Results

The mean number of trials to criterion for the high response frequency list was 12.65 ($SD = 6.17$) and 20.70 ($SD = 7.71$) for the low response frequency list. A two-tail t test indicated that this difference was significant [$t(38) = 3.65$, $p < .001$]. The mean error rate for the high response frequency list was 2.76 ($SD = 1.00$) and 3.63 ($SD = 0.89$) for the low response frequency list. This difference was also significant as indicated by a two-tail t test [$t(38) = 4.14$, $p < .001$]. The results of the replication experiment therefore closely parallel the original experiment in indicating that performance on high response frequency paired associates significantly exceeds performance on low response frequency paired associates.

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NOTE

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Influence of four input conditions on serial output

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The influence of four input conditions on serial output was investigated in a replication of earlier studies by Slamecka and by Heslip. Groups of 28 Ss learned a list of 10 consonants when the cues to correct serial order were temporal input order or spatial location of items. Temporal contiguity of items in input produced more rapid acquisition than spatial information. Ss with both sources of order information learned no faster than Ss with only temporal input order as a source of information for required output.

Slamecka (1967) has studied the influence of input conditions on serial output. Different groups of Ss with the same output requirements received different sources of serial order information in input. Group 1 had temporal input order corresponding to the required output order. Successive items were presented on a memory drum in the same spatial location. Group 2 had spatial separation of items in input as a cue to required output. Temporal input was unrelated to the correct serial output. Slamecka found no difference in rate of acquisition for Groups 1 and 2. He concluded that spatial separation of items was as good a cue to serial order as temporal contiguity. Group 1 could have learned the list by forming interitem associations, by learning the location of each item in the list, or by a combination of both. Group 2, on the other hand, was forced to rely on spatial information to learn the list. Consequently, Slamecka concluded that the fundamental process in serial acquisition involves learning the location of the items rather than forming associations between the items.

Heslip (in press) replicated Groups 1 and 2 in Slamecka's (1967) Experiment 2. In addition, a third group was added which had both temporal input order corresponding to required output order and spatial separation of items in input as a cue to required output. In that study, Group 1 learned significantly faster than Group 2, but Groups 1 and 3 did not differ in rate of acquisition. Heslip concluded that temporal contiguity of items was more important than spatial separation of items for rapid serial acquisition. It was also concluded that when Ss had both explicit spatial cues and temporal contiguity of items as sources of serial order