Bidirectional List 2 learning and the A-B, C-A transfer paradigm[1]

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A paired-associate transfer experiment, using CVC lists, compared the A-B, C-A paradigm to the A-B, C-D control. The second variable in the factorial design was the direction of List 2 learning, either forward or bidirectional. List 1 was practiced until learned, and List 2 until two successive errorless trials. Bidirectional learning was reliably slower than forward learning alone. A follow-up test of List 1 associative matching, using A-B, C-D as the baseline, showed reliable unlearning for the bidirectional A-B, C-A group, falling short with the forward learning group. Additional sources of List 2 facilitation apparently compensated for the added bidirectional interference.

As a consequence of recent experiments (Schulman, 1967a; Schulman, 1967b) it has been concluded that the paradigm studied here produces associative interference to List 2 acquisition, but that its effect may be counterbalanced because of facilitation from the gain in availability of the repeated terms. It should be emphasized that the finding of positive transfer for the A-B, C-A paradigm came from a situation involving a low degree of List 1 learning. Therefore, it may reflect a lack of substantial interlist interference rather than a substantial facilitation from repeating the stimuli of List 1 as the responses of List 2. One possible further implication of the above conclusion is that interfering with the formation of the List 2 backward association has a negative effect on the formation of the forward association. An alternative statement of this interpretation is to say that there is less than complete independence between the backward and the forward association (Johnston, 1967, p. 515).

The question of interest in this experiment is the change in the number of trials to reach List 2 performance criterion, and the followup List 1 associative matching scores, as a result of requiring List 2 to be learned bidirectionally. Setting a List 1 criterion of one errorless trial assures substantial interlist interference. It is realized that paired-associate learning with the conditions used brings other components such as response-learning into the total task. However, had the bidirectional condition resulted in doubling the total number of trials to List 2 criterion, it would have been possible to claim that all components had doubled in difficulty. Independence of the backward and the forward associative connection leads to the expectation of the doubling in number of trials required for this component. It does seem likely that the net result of trials to final criterion includes less than doubling of the response learning component. Because there should be some gain in the availability of the stimulus terms when learning proceeds in a given direction, then there would be facilitation to the response learning phase of learning in the other direction. In the case of the A-B, C-A paradigm, it was believed that the List 2 associative learning component should increase more in difficulty to the bidirectional condition than for the A-B, C-D control. This is because the backward List 2 trials of A-B, C-A function as A-B, A-C, which has been found to reliably produce associative interference to List 2 learning. Whether this greater magnitude of difficulty increase to the bidirectional condition for the A-B, C-A associative learning component would be paralleled in the number of trials to criterion, could not be predicted. The followup test of List 1 associative matching was intended to provide some indication of the relative magnitudes of interlist associative interference generated by the four combinations of conditions.

METHOD

Eighty Army enlisted men were the nonvoluntary Ss. They were nonsystematically selected from the available population on the basis of having a GT (General Technical) score on the Army Classification Battery (ACB, Dept. of Army, 1961) of over 100. The four groups of Ss, 20 per group, may be schematized as follows:

1. A-B, C-D; List 2, one-way
2. A-B, C-D; List 2, two-ways
3. A-B, C-A; List 2, one-way
4. A-B, C-A; List 2, two-ways

The verbal units used were CVCs. Initial consonants were not repeated on the stimulus side, the response side, or across S-R pairs. The average rated number of associations (a') according to Noble (1961), was 2.24 for the List 2 stimuli and 2.16 for the List 2 responses (1-few, 5-many). The third list, used as the responses of List 1, had an average Noble (a') rating of 2.76. The fourth list, used as the stimuli of List 1 for the A-B, C-D control, had an average (a') of 2.11.

Standard instructions for the Study-Test procedure were taped and played to each S. The verbal materials were presented by means of a Kodak Carousel projector, each slide visible for 3.0 sec. Change-time necessitated a .75 sec blank interval between slides. There were 6 sec between trials and 20 sec between List 1 and List 2. The first list was learned until one errorless recitation was given; List 2 was practiced until two consecutive errorless recitations were given. After List 2 was completed, approximately 30 sec were required to prepare for the test of associative matching. Ss, whose GT scores fell between 100 and 130, completed the matching test at their own rates of speed. Less than 1/2 min was generally required.

RESULTS

List 1 learning data showed that the four groups required 11.65, 11.95, 15.45, and 12.40 trials, respectively, to reach the criterion of one errorless trial. A factorial analysis of variance indicated that the main effect of difference between paradigms (which for List 1 in this experiment simply indicates that there were two sets of stimuli) was reasonably high ($F = 3.55$, $df = 1/76$, $.05 < p < .10$) but still not reliable. It is quite apparent that the Group 3 data are responsible for the magnitude of the F ratio. However, the average GT scores of the four groups were virtually identical–113.70, 112.65, 112.85, and 112.05 respectively. Also, at the criterion of 3/6 Group 3 was not apparently divergent (4.75, 5.30, 5.65, and 4.05 trials respectively). The main effect comparing Groups 1 and 3 to Groups 2 and 4 was also not reliable ($F = 1.49$, $df = 1/76$, $p > .20$). Since the variable of bidirectional vs unidirectional learning was not a factor in List 1 acquisition, no difference had been expected. The interaction between the two main effects also failed to reach the level required for statistical significance ($F = 2.24$, $df = 1/76$, $.10 < p < .20$).

List 2 learning functions (see Fig. 1) show that the bidirectional condition required more trials than the condition for which performance in only the forward direction was required. A factorial analysis of variance performed at the criterion of two successive errorless trials showed the main effect of List 2 learning direction to be statistically reliable ($F = 14.42$, $df = 1/76$, $p < .001$). Figure 1 also shows that transfer direction for A-B, C-A tended to be negative at the unidirectional level of List 1 learning, and was just barely in the positive direction at the bidirectional level of List 2 learning. However, the analysis of variance failed to substantiate this apparent interaction ($F = 1.00$). As would be expected from the apparent reversal in direction of transfer, the main effect of difference between paradigms also failed to reach the level required for statistical significance ($F = .65$).

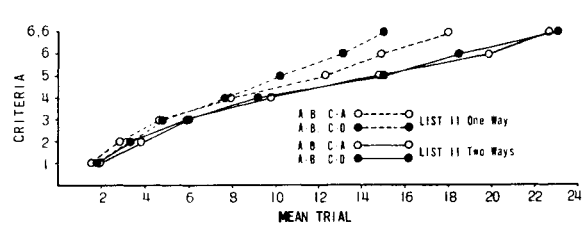

Fig. 1. Mean trials to reach successive criteria during List 2 learning.

The followup test of List 1 associative matching resulted in data which radically departed from a normal distribution. Median numbers of pairs correctly matched by the four groups were 5.73, 5.59, 4.17, and 3.50, respectively. Mann-Whitney U tests were computed to compare the four simple effects between the two variables. Only the difference between Groups 2 and 4 (U = 129.5), comparing the A-B, C-D, and the A-B, C-A paradigms at the bidirectional List 2 level, passed the magnitude required by the one-tailed test at the .05 level (U of 138). Considering the groups which learned List 2 in only the forward direction, the difference between the A-B, C-A paradigm and the A-B, C-D control paradigm resulted in a U of 150.5. The comparison between groups differing in learning direction within the A-B, C-D paradigm resulted in a U of 161.5; within the A-B, C-A paradigm the U value was 168.5.

DISCUSSION

It seems apparent that the effect of List 2 bidirectional learning on the difference between paradigms was opposite to what had been expected from consideration of the associative learning component. Requiring List 2 to be correctly performed in both directions has eliminated the small magnitude of negative transfer observed with only forward learning. Although not supported by the statistical analysis, the change in transfer direction between List 2 directions at the final learning criterion, amounting to an algebraic difference of about three trials, is worthy of note. Proper interpretation requires consideration of the List 1 learning data, which showed Group 3 to be about three trials slower than Group 4 in reaching the learning criterion. As identical lists are contributing to this comparison, it is likely that the Ss in Group 3 are on the whole somewhat slower learners than those in Group 4. Comparing Groups 1 and 2, which learned the same list of verbal units, it can be seen that the number of trials to complete acquisition are approximately the same. Since there is no reason to believe that the two versions of List 1 differ in ease of learning, and since Group 4 required about the same number of trials as Groups 1 and 2, it would seem that Group 3 contained the atypical (slower learning) Ss. Viewing the List 2 acquisition data in this light leads to the conclusion that the relationship between the A-B, C-A transfer paradigm and the A-B, C-D control paradigm is virtually unaffected in number of trials to criterion by the bidirectional condition of List 2 learning.

Although the bidirectional List 2 groups were reliably slower than those which required performance in only the forward direction, it is interesting that the number of trials required for the A-B, C-D paradigm (23 and 15) show an increase of only about 50%. It is thought that an important factor in the failure to get double the number is lack of independence on the part of the backward and the forward response learning components. Functioning as the stimulus term for one direction would have the effect of adding to the availability for the opposite direction of performance. Another factor may be a gain in differentiation of the response list which would then facilitate learning in the opposite direction when functioning as the stimulus list. Also possibly contributing to the faster than expected bidirectional List 2 learning may be the fact that the forward and the backward direction typically did not require the same number of trials to reach criterion. The preprogrammed sequence of alternating backward and forward trials might then supply covert rehearsal time for the not yet learned associations, during the presentation of the pairs in the already learned direction. With these qualifications it seems reasonable to claim that the current data for the A-B, C-D paradigm are not incompatible with the idea of somewhat less than complete independence of the backward and the forward associative component of learning. But it is more difficult to explain why the apparent increase in number of trials to the final learning criterion for the bidirectional List 2 condition, when the increase is adjusted for supposed learning effectiveness differences between groups, is about the same for the A-B, C-A paradigm as for the A-B, C-D control. It seems necessary to invoke the rehearsal function of forward learning trials after forward learning has been achieved, while recognizing that it is mainly the backward trials which are subject to the interference from List 1 learning. Another factor which may have a greater magnitude of effect on A-B, C-A because of associative interference having a greater effect on a more stringent criterion, involves the nature of the criterion used in the bidirectional condition. Two correct forward performances in a row required an average of about two trials past the criterion of one errorless performance. In the case of backward performance trials in the bidirectional condition, it is believed that the first occurrence of an errorless backward trial occurs on the average more than two trials before the trial on which the second consecutive errorless backward performance could take place.

The final test of associative matching, which is believed to reflect both forward and backward List 1 associations, has resulted in little if any difference in the magnitude of List 1 unlearning between the unidirectional and the bidirectional List 2 conditions. Although this outcome does not seem to encourage the belief in the independence of the backward and the forward associative connection, differential magnitude of List 1 unlearning between List 2 conditions is not believed to be a necessary requirement for their independence. Also, it is considered a possibility that the conditions of this experiment were not such as to maximize the effect. For one thing, it is quite possible that had Group 3 been equal to the others in learning effectiveness, it would have averaged higher on List 1 recall and the A-B, C-A paradigm would therefore have shown a greater apparent reduction in List 1 recall to the bidirectional condition. Furthermore, there is no reason to expect much change in List 1 recall of the A-B, C-D paradigm due to the addition of backward List 2 acquisition. Additional consideration is warranted to the 1.5 trial difference between the medians of groups which had only forward List 2 learning. Although not reaching the level usually required for statistical reliability, it suggests that some List 1 unlearning did occur. This interpretation is supported by Garskof's (1968) finding that there is some unlearning of specific associations for A-B, C-D. It is concluded that although the existence of interlist associative S-R interference has been demonstrated, the relative independence of the backward and the forward components of associative learning has greatly reduced its effect on List 2 in the A-B, C-A paradigm. Of further interest is the relative magnitudes of A-B, C-A List 1 unlearning at the two conditions of List 2 learning direction. Although they show greater interlist interference for the bidirectional group, the List 2 acquisition functions show a negative direction of transfer only with the unidirectional group. This contrast leads to the conclusion that the bidirectional learning condition of List 2 brings about additional sources of facilitation which are not operating in the unidirectional condition.

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NOTES

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