Cue utilization in serial learning¹

LOUIS G. LIPPMAN, *Western Washington State College, Bellingham, Wash. 98225*

Four experimental groups ($N = 24$ each) in which the intertrial interval (ITI) was shifted to the middle of the 12-item list after S attained at least 1, 4, 7, or 10 correct anticipations on a single trial (Groups E_1 , E_4 , E_7 , and E_{10} , respectively) were compared to a control group ($N = 24$) in which the ITI maintained a constant location. The results showed no significant impairment in performance for Groups E_4 and E_7 , a temporary decrement for E_{10} , and a more extended decrement for Group E_1 , supporting predictions based upon the extent to which S is dependent upon the ITI for maintenance of the cue value of the first item and the extent to which S has acquired a set regarding the location of the ITI within the series. It was suggested that interference effects were minimized in the present experiment due to the visual identity of the ITI to the inter-item space.

Once the intertrial interval (ITI) has established the first item as anchor for the serial position effect (Jensen, 1962; Lippman & Denny, 1964), it may be asked whether the ITI must hold a constant position in the series in order to maintain the cue value of the first item. Jensen has shown that S learns a temporal series from both ends, working from the first item toward the middle items of the series. Furthermore, Lippman and Denny have shown that primacy effects occur almost immediately while several repetitions of the list are required before recency effects begin to accrue (before performance on end items exceeds middle items). It may thus be asserted that early in learning S is highly dependent upon the ITI for a cue. So if the position of the ITI were shifted before the first item had been learned (learned both as a response and as a cue), then extensively impaired total-list performance would be expected. Late in learning, S has already used the ITI as a cue for acquisition of the beginning of the list and as a cue for learning the end of the list. Changing the location of the ITI late in acquisition, therefore, should probably produce a slight impairment in performance as the result of change in stimulus conditions (which may be viewed as generalization decrement or as interference with an acquired set). At an intermediate stage of acquisition, however: (1) the first item has been learned as a response and, with the ITI, has served to produce learning of not only the beginning of the list, but acquisition of items at the end of the series as well; (2) having been supplanted by the first item, the ITI has become a redundant cue upon which S is no longer highly dependent; and (3) a set with regard to the locus of the ITI has not acquired much strength.

If these assumptions hold true, then a change in location of the ITI, during an intermediate stage of acquisition, would produce at the most a small, temporary performance decrement. Minimal performance decrement will probably occur only if all three conditions above can be satisfied and if the ITI is highly similar to the interstimulus interval (no asterisks present). It is assumed that decreasing the distinctiveness of the ITI reduces the strength of the association between the ITI and first item; and thus minimizes interference effects which would occur as a result of switching the ITI to the middle of the series.

The purpose of the present study is to test for differential effects in total-list performance as the result of changing the location of the ITI from the end to the middle of the list after different levels of acquisition have been reached.

METHOD

The S s were 120 students enrolled in an introductory psychology course at Michigan State University. Each S was systematically assigned by rotation to one of five groups, according to his order of appearance at the laboratory. The S s were instructed to spell their anticipations; that the

syllables would always appear in the same order; and that the syllables would be presented alternately with blank spaces. All S s were uninformed of the shift in ITI location.

The apparatus consisted of an MTA 100 Scholar (teaching machine) and an MTA external timer, wired so the E could insert a delay (ITI) at any position in the series by pressing a silent push-button (thus activating a Hunter timer). Twelve CVC trigrams, identical to those used by Lippman and Denny, were presented alternately with blank spaces. Each syllable was presented for 1.5 sec, each blank space for 1.5 sec, and an ITI consisted of a 9-sec presentation of a blank space. The syllables were always presented in the same order, but 12 different starting positions were employed with two S s in each group beginning their learning from each of the 12 starting positions.

Four experimental groups (E_1 , E_4 , E_7 , E_{10}) continued in acquisition until attaining at least 1, 4, 7, or 10 correct anticipations on a single trial; this partial criterion was defined according to each S 's individual rate of acquisition. After an S reached partial criterion (according to the assigned experimental group) the location of the ITI was shifted from the end of the list (blank space between Items 12 and 1) to the middle of the list (blank space between Items 6 and 7) on the trial immediately following attainment of the partial criterion. Following the shift in location of the ITI, all experimental groups continued learning until attaining perfect recitation of the list on one trial (defined in reference to the changed ITI location). Finally, the control group (Group C) continued learning to a criterion of one perfect recitation without a shift in ITI location.

RESULTS AND DISCUSSION

Serial Position Effects

The data of all five groups are presented graphically as serial position curves in Fig. 1. Group C produced a bow-shaped serial position curve, indicating that the present procedure produced fairly typical serial performance despite some departure from conventional methods of presentation. The atypical finding, that the first item tended to be anticipated correctly less frequently than the second item, can be attributed to the absence of a distinctive cue (asterisks)

Fig. 1. Serial position curves for groups C, E_1 , E_4 , E_7 , and E_{10} , plotted in reference to the ITI's original location.

Table 1
Number of Correct Anticipations Following Partial Criterion per Trial for each E-group with Analogous Measures Derived from Group C

	C ₁	E ₁	C ₄	E ₄	C ₇	E ₇	C ₁₀	E ₁₀
M	6.27	5.49	7.16	7.20	8.55	8.37	9.89	9.35
SD	0.87	1.22	0.83	0.74	0.73	0.84	0.81	0.72

preceding the initial item of the series. Since Ss were not explicitly informed of the onset of each trial, many Ss waited for the appearance of the first item before making an anticipation. The shift in location of the ITI produced differential "isolation" effects in the middle of the series for the E-groups. The magnitude of these isolation effects is related to the proportion of trials in which the ITI was located between the sixth and seventh items. It is also of interest to note that for group E₁ the ITI remained in its original location for an average of only 3.79 trials (11% of the total number of list presentations, on the average). Despite the fact that nearly 90% of all trials for Group E₁ started from the middle of the series, performance at the beginning and middle of the series is nearly equal. It thus appears that the cue-value of the first item is established at the outset of acquisition; and that Ss continue using this "originally first" item as a cue throughout the remainder of acquisition, despite a shift in the location of the ITI which takes place early in learning. This interpretation is in keeping with Lippman and Denny's assertion that seeing an item as "first" on only one trial is sufficient to enhance the discriminability of that item.

Total List Performance

All five groups were compared on trials to correct anticipation of at least one item; Groups E₄, E₇, E₁₀, and C were compared on trials to correct anticipation of at least four items on a single trial; Groups E₇, E₁₀, and C were compared on trials to at least seven correctly anticipated; and Groups E₁₀ and C were compared on trials to at least 10 items correctly anticipated. None of these four analyses of variance was significant ($p > .05$), thus indicating that the five groups were homogeneous in acquisition.

In order to test the present hypotheses directly, the mean number of correct anticipations following partial criterion per trial was calculated for each S in the E-groups and four corresponding measures were derived for Ss in Group C, as shown in Table 1. (Trials were defined in reference to the ITI's original location for all groups. The last half of Ss' last trial in all E-groups was thus scored as half of a trial.) Four t tests between each E-group and its appropriate C measure revealed overall impairment in performance in Groups E₁ and E₁₀ [$t(46) = 2.52$, $p < .05$; $t(43) = 2.35$, $p < .05$, respectively] and no significant difference in Groups E₄ and E₇ [$t(46) = 0.17$, $t(46) = 0.78$, respectively].

The effect of shifting the location of the ITI upon subsequent performance was directly examined in the first two trials following the shift, the third and fourth trials, and in the fifth and sixth trials following partial criterion. For each of these three analyses, the mean total correct anticipations was obtained. For each measure in each E-group, an appropriate corresponding measure was derived from Ss in all available groups since a score could not always be obtained for all Ss due to Ss reaching criterion soon after attaining partial criterion (as in the E₁₀ vs C comparison above). This procedure was adopted in preference to assuming continued perfect recitation after one perfect trial. Thus Group E₁ was compared to combined measures derived from Groups C, E₄, E₇, and E₁₀; Group E₄ was compared to C, E₇, and E₁₀; Group E₇ was compared to measures derived from Groups C and E₁₀; and Group E₁₀ was compared with Group C. The shift in ITI location did not significantly affect performance in Groups E₄ and E₇ (all $ts \leq 0.65$ for Group E₄; all $ts \leq 0.75$ for Group E₇). Group E₁ showed impaired performance on all three blocks of trials [$t(116) = 2.63$, $p < .01$; $t(109) = 2.00$, $p < .05$;

$t(102) = 2.33$, $p < .02$; for the first, second, and third blocks of trials, respectively]. For Group E₁₀, performance was significantly impaired on the first two trials following partial criterion [$t(43) = 3.88$, $p < .01$] but did not differ from Group C thereafter [$t(40) = 1.48$; $t(31) = 0.45$, for the second and third blocks of trials, respectively].

Finally, an analysis of variance on trials to criterion was performed as an overall comparison of groups' performance. The F was not significant [$F(4,115) = 1.44$, $p > .05$].

It is of interest to note that the groups did not differ on trials to criterion and that two of the E-groups never differed from the control condition when fairly sensitive measures of performance were employed. On the basis of previous research using the varied-position method (continual shift of ITI position), a change in the location of the ITI may be expected to impair performance. The present procedures however, employed an ITI which differed temporally but not visually from the interstimulus interval (blank space); which should minimize and thus underestimate the interference effects from a shift in the location of the ITI. Greater performance decrement might have occurred had the ITI differed both temporally and visually from the interstimulus interval; this possibility would be consistent with Lippman and Denny's assertion that the cue value of the ITI is highly dependent upon its perceptual distinctiveness.

When the E-groups were compared to Group C on mean number of correct anticipations following partial criterion per trial, the predicted effects were found—i.e., no effect in Groups E₄ and E₇ and a decrement in the performance of Groups E₁ and E₁₀. Additional testing of performance on the first, second, and third pairs of trials following partial criterion further substantiated the results based upon the mean number of correct anticipations following partial criterion. And these more specific tests pin-point when the effects occurred. It is of prime importance to note that during the first two trials following partial criterion, all Ss in the E-groups were exposed to novel or changed stimulus conditions. The fact that Groups E₄ and E₇ showed no impairment in performance on these trials supports the contention that, at an intermediate stage of learning, the set regarding the locus of the ITI has not acquired much strength. And the fact that these two groups failed to show a decrement in performance on the two subsequent pairs of trials offers support for the contention that Ss at intermediate stages of learning are no longer very dependent upon the ITI as a cue; that the first item has perhaps adopted a cue function, or supplanted the ITI as a cue.

Group E₁₀ showed a significant drop in performance on the first two trials following partial criterion (when exposed to changed stimulus conditions), but did not show a decrement on the four trials thereafter. This finding of a temporary performance decrement supports the prediction that when Ss are near criterion performance, they are not highly dependent upon the ITI as a cue, but instead have acquired a set regarding the location of the ITI. Finally, Group E₁ showed a significant drop in performance on all three pairs of trials following partial criterion. This finding of an extended performance decrement is in keeping with the prediction that early in learning Ss have not acquired a strong set concerning the location of the ITI, but instead Ss are highly dependent upon the ITI for a cue. When this cue is changed, a long-term decrement in performance is expected since the first item has not yet been learned both as a response and as a cue.

REFERENCES

- JENSEN, A. R. An empirical theory of the serial-position effect. *Journal of Psychology*, 1962, 53, 127-142.
- LIPPMAN, L. G., & DENNY, M. R. Serial position effect as a function of intertrial interval. *Journal of Verbal Learning and Verbal Behavior*, 1964, 3, 496-501.

NOTE

1. A version of this paper was presented at the 1967 meeting of the Western Psychological Association.