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CONTEXTUAL ASSOCIATIONS AND MEMORY FOR SERIAL POSITION [1]

DOUGLAS L. HINTZMAN,[2] RICHARD A. BLOCK, AND JEFFERY J. SUMMERS

University of Oregon

Three experiments used a combination list-discrimination and position-judgment task to investigate the role of contextual factors in incidental memory for serial position. In Experiment I, two temporally defined lists were presented; in Experiments II and III, there were four and three lists, respectively. Following presentation of the lists, *S*s made judgments of the list membership and within-list position of test words. Judgment frequencies revealed: (*a*) a temporal factor, affecting list identification and producing strong primacy and recency effects; and (*b*) an effect of position, when more than two lists were used, such that a word assigned to an incorrect list still tended to be placed in the correct within-list position. When the retention interval was lengthened the effects of primacy and within-list position were unaffected, while the effect of recency was reduced. An interpretation is offered which assumes judgments of serial position are based on contextual associations.

If *S* is shown a list of words, and one of them is later presented as a probe on a memory test, *S* is not only able to say that the word occurred in the list, but in addition he knows something about the serial position the word occupied (Hintzman & Block, 1971; Zimmerman & Underwood, 1968). This ability is prima facie evidence for the existence of some sort of "time tag." The time tag is of general theoretical interest because it could play an important role in many memory tasks: In recognition memory *S* must know that an item was presented during the experiment, in short-term retention that it occurred on the current trial, and in a variety of other tasks that it occurred in a particular temporally defined list. The possible mediating function of the time tag in such situations is obvious.

What is the nature of the time tag? One approach to this question is to postulate some retrievable property of the memory trace the magnitude of which changes monotonically with the trace's age. Hinrichs (1970), for example, has proposed that judgments of recency are based on the trace's decaying strength, while Wickelgren (in press) has suggested that they may be based on a property of the trace—its "resistance"—which grows over time. A second approach is to assume that memory is inherently chronologically ordered, much as is a tape recording. This was the basic hypothesis underlying Koffka's notion of the "trace column" (Hintzman & Block, 1970; Koffka, 1935, pp. 438–448).

There is one experimental outcome, however, that seems inconsistent with either of these approaches. Hintzman and Block (1971, Experiment I) found that the slope of the function relating judgments of serial position to actual serial position was greater near the beginning than near the middle or end of a list. The discriminability of time tags was apparently affected more by the primacy of words in the list than by their recency. Neither the decreasing strength nor the increasing resistance construct predicts this outcome, since in both cases the underlying quantity is assumed to

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[2] Requests for reprints should be sent to Douglas L. Hintzman, Department of Psychology, University of Oregon, Eugene, Oregon 97403.

change less rapidly the older the trace becomes, and so the recency effect should be greater. And in the trace column model, locations near the end of the list should be as discriminable as locations near the beginning, and so one would expect the primacy and recency effects to be about equal.

A third approach, which is suggested by the strong primacy effect in that study, is to identify the time tag with contextual information. Anderson and Bower (1972), for example, have assumed that when a word is presented it becomes associated with elements of the cognitive context in which it is embedded. Some of these associations, when retrieved on a later test, may provide information about the position the word occupied in the list. Subjectively, this seems to be the case. As was noted by Bartlett (1932, p. 56), the retrieval of an item from memory is often accompanied by an associated feeling (e.g., confidence, mild despair, or anticipated relief) which allows a rough judgment to be made regarding where in the list the item occurred. The explanation of the strong primacy effect, in this account, rests on the plausible assumption that the relevant contextual cues change most rapidly during presentation of the first few experimental items.

The purpose of the present experiments was to provide evidence for the role of contextual associations in judgments of serial position. In what was disguised as a recognition memory task, *S*s were presented with more than one list. They were then asked to give, for certain test words, a judgment of each word's list membership and of its position within the list. The critical question involves those words that *S* assigns to an incorrect list. The strength, resistance, and trace-column hypotheses, since they assume that the underlying position cue is strictly correlated with time, all predict that words will tend to be placed in positions temporally close to the correct position. For example, words from the end of List 1, if assigned to List 2, should be assigned to the beginning of that list. In contrast, the contextual association hypothesis predicts that, to the extent that contextual elements can be manipulated independently of time, this will not be the case. If similar contextual elements prevail at corresponding serial positions in different lists, then the tendency should be for the correct position to be given, even when list identification is incorrect.

Experiment I

In this experiment, two lists of words were used. In order to disguise the true nature of the task, a short recognition memory test was given immediately following each list. Only words from the middle portions of the lists were used on these tests. Following the List 2 recognition test, a position-judgment test was given which involved words from near the beginnings and ends of both lists, and which required *S* to make combined judgments of list membership and within-list serial position.

Method

Materials. A total of 130 three-letter nouns were selected as experimental items. Two 40-word lists were constructed by randomly selecting 80 of these words and assigning each to a position within one of the lists. A slide of each word was constructed by typing the word on white paper and mounting in an Easymount slide frame. For each list, the 40 slides were then arranged in a continuous sequence in a Kodak Carousel slide tray.

Two separate recognition test sheets were used, one for List 1 and one for List 2. Each was composed of the 20 words from the middle (Positions 11–30) of the appropriate list, randomly intermixed with 20 distractor (new) words.

A test sheet for judgments of list membership and position was composed of 10 words from each of five conditions, representing the beginning (Positions 1–10) of either list (Conditions 1B and 2B), the end (Positions 31–40) of either list (Conditions 1E and 2E), and distractor words (Condition N). On the test form, these 50 words were listed in a random order in two columns. Following each word were six alternatives: the letters B, M, and E (for beginning, middle, and end) under the heading List 1, and the same letters under the heading List 2. The same test form was used for all *S*s. Words were rotated among Conditions 1B, 1E, 2B, and 2E between experimental sessions.

Subjects. The *S*s were 34 paid volunteers obtained through the University of Oregon employment office. They were run in groups of up to 5 *S*s each. The data of 3 additional *S*s were discarded because of failure to follow instructions.

TABLE 1

RELATIVE FREQUENCIES OF USE OF RESPONSE CATEGORIES FOR OLD AND NEW WORDS, EXPERIMENTS I AND II

Response category	Words: Old	Words: New
Experiment I		
1B	.14	.12
1M	.21	.31
1E	.14	.29
2B	.21	.13
2M	.22	.09
2E	.08	.06
Experiment II		
1B	.08	.11
1E	.10	.24
2B	.15	.16
2E	.15	.19
3B	.17	.11
3E	.15	.11
4B	.13	.06
4E	.07	.02

Procedure. At the outset of the experiment, *S*s were told that a series of 40 words would be shown, and that they were simply to study each word for as long as it was presented and try to remember it for a later test. List 1 was then presented by a Kodak Carousel projector set at a 5-sec. rate. At the conclusion of List 1, *S*s were given the first recognition test sheet and asked to indicate whether or not each word has been presented during the series of slides. After *S*s finished the recognition test, they were told that another series of 40 words would be shown and that the task was the same. About 5 min. separated the end of List 1 and the start of List 2. After List 2 had been presented *S*s were given the second recognition test. When they had finished, they were given the test sheet for their judgments of list membership and position. This was the first indication that there would be no List 3. The *S*s were told to circle one of the six alternatives for each word, basing their choice on whether they thought the word was presented during the first series of slides (List 1) or the second series of slides (List 2) and whether the word occurred nearest the beginning, middle, or end of the list (the response new was not allowed). If uncertain, they were told to guess. About 5 min. separated the end of List 2 and the start of this test.

Results

Judgments were not evenly distributed over the six response categories: There was a marked tendency to avoid using the extremes 1B and 2E, and to overuse 1M. In addition, it was found that these response biases were different for the 10 words which had not been presented than for the 40 words which had; new words

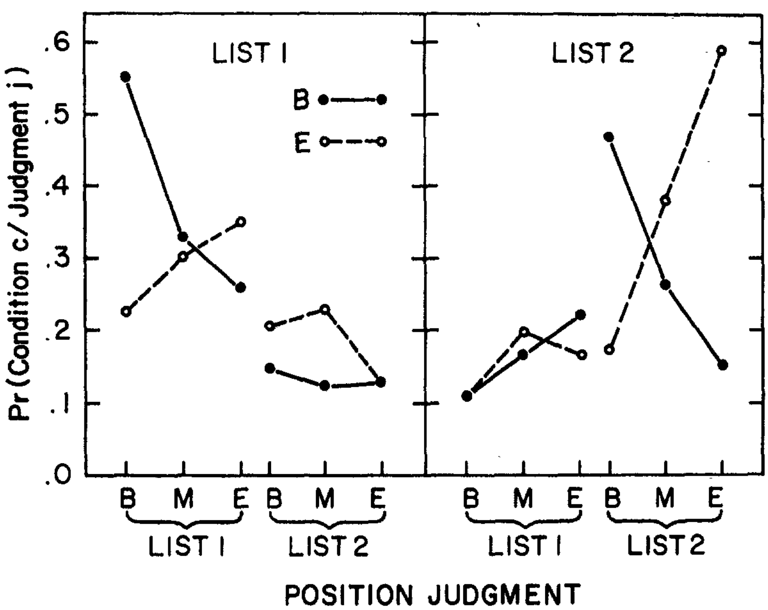

FIG. 1. Corrected response probabilities for the 4 conditions (2 Positions × 2 Lists) of Experiment I.

were more likely than old words to be assigned to early (less recent) positions. Response proportions for Experiment I for old and new words are presented in the upper part of Table 1.

Because of the unequal distribution of judgments across categories, and across new and old items, response proportions were corrected for overall response tendencies to old words by computing a posteriori probabilities (P), with responses to new words deleted. In Figure 1, P (Condition $c|$ Judgment j) is plotted as a function of j, separately for each of the four conditions. The curves can best be described as generalization gradients over the temporal dimension. In each condition, the most probable response is the correct one, and response probability declines with temporal distance. There are no systematic deviations from this pattern. In particular, the expected tendency for words assigned to the wrong list to be placed in the correct part of that list (especially 1E words in 2E and 2B words in 1B) was not observed.

Each S's response frequencies were corrected for individual bias by computing a posteriori probabilities, square-root transformed, and subjected to an analysis of variance using planned comparisons. The analysis showed that category choices were affected both by the correct list, F (1, 33) = 69.7, $p < .001$, and by the correct position within the list, F (1, 33) = 32.5, $p < .001$. However, the effect of correct position was not significant when the correct list was excluded, F (1, 33) = 2.93, $p > .05$. This last comparison is the one that would be expected to show the generalized effect of context.

There were two results of this experiment that were unexpected. One surprise was the failure of within-list position to generalize when words were assigned by S to the wrong list. The other concerned the relative magnitudes of the primacy and recency effects. Performance on 2E words turned out to be about as accurate as that on 1B words. This is not what the contextual association hypothesis led us to expect, and it seemingly contradicts the outcome of our previous study using a single list (Hintzman & Block, 1971, Experiment I). It is, however, consistent with the finding of Rothkopf (1971) regarding memory for location of information in meaningful text. Both these surprises stimulated further experimentation.

Experiment II

Why did Experiment I fail to reveal an effect of manipulated context? One possibility is that the cognitive context of List 1, since its presentation represented a new experience for S, was quite different from that of List 2. Another possibility is that the corresponding parts of the two lists were so spread out in time that some temporal factor completely overrode the effect of within-list position. Either of these explanations suggests that if more than two, shorter lists were presented, the expected generalization of within-list position should be observed. Accordingly, in Experiment II the 80-word sequence was divided into four rather than two lists, and the M category was eliminated from the judgment scale in order to keep the number of categories reasonably small.

Method

Materials. The experimental items were the same 130 three-letter nouns used in Experiment I. Eighty of the words were assigned randomly to four lists of 20 words each. Four recognition test sheets were used, each composed of a random ordering of the 10 words from the middle (Positions 6–15) of one of the lists and 10 distractor words. The test sheet for judgments of list membership and position was presented in two forms. This was done to assess the effect of the perceptual organization of the judgment scale on position judgments. Each form was composed of the words from Positions 1–5 of each list (Conditions 1B, 2B, 3B, and 4B), those from Positions 16–20 (Conditions 1E, 2E, 3E, and 4E), and 10 new words. On one form of this test, these 50 words were randomly ordered in two columns, and the eight alternatives were typed in a single row to the right of each word, in the order: 1B, 1E, 2B, 2E, 3B, 3E, 4B, 4E. On the other form, the same 50 words were typed in three columns, and the eight alternatives were typed in two rows next to each word, with alternatives 1B, 2B, 3B, and 4B directly above 1E, 2E, 3E, and 4E.

Subjects and procedure. The Ss were 52 paid volunteers, run in groups of up to 5 Ss each. Within each group, about half of the Ss received either form of the test of list membership and position. The

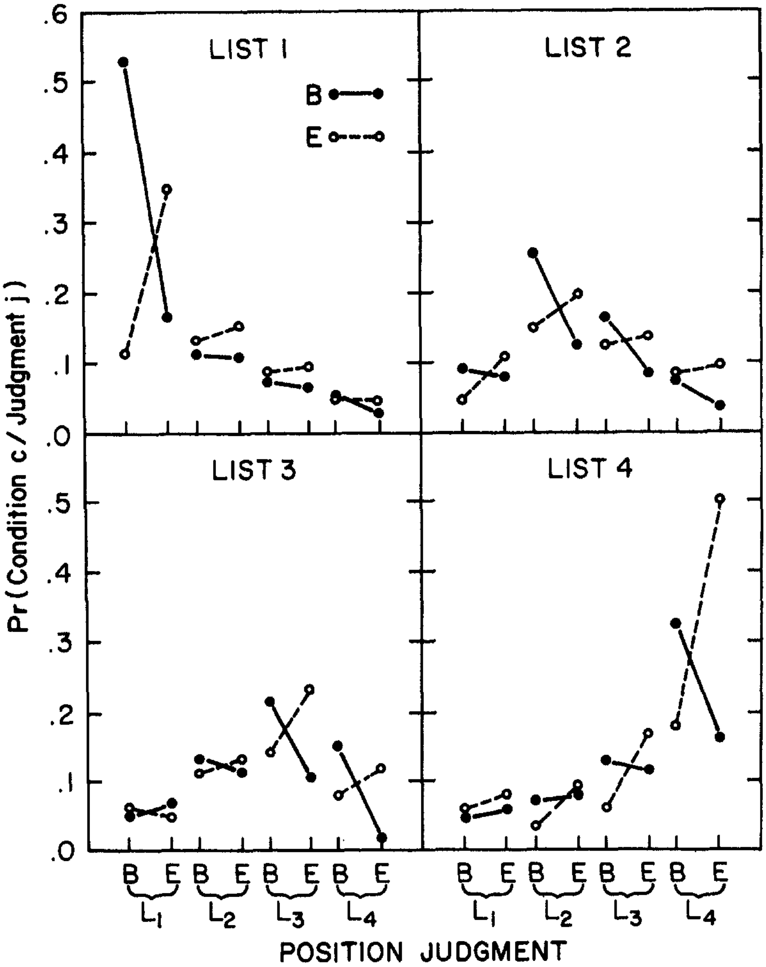

FIG. 2. Corrected response probabilities for the 8 conditions (2 Positions × 4 Lists) of Experiment II.

experimental words were rotated through the eight experimental conditions between sessions.

Before each list was presented, *S*s were told only that a series of 20 words would be shown and that they were to try to memorize each word. Presentation was at a 5-sec. rate. After each list had been shown, the appropriate recognition test was given. About 2.5 min. separated the end of one list and the start of the next. Following the fourth recognition test, *S*s were given the test form for judgments of list membership and position. They were told to circle one of the eight alternatives for each word, basing their choice on the series of slides in which the word occurred and on whether it occurred closer to the beginning or closer to the end of that series. The *S*s began this final test about 4 min. after the end of List 4.

Results

Overall use of the eight judgment categories in Experiment II is presented in the lower part of Table 1. As was the case with Experiment I, *S*s tended to use the most extreme categories least often. Also in accordance with Experiment I, they distributed their judgments to old and new words differently, using less recent categories most often in judging positions of new words.

Response proportions to old words were again used to compute a posteriori probabilities, and these are presented separately for words from each list in Figure 2. Since the form of the test sheet (judgments arranged in one vs. two rows) had no apparent effect on performance, data from both forms have been combined. Two factors affecting position judgments can be identified in Figure 2. First, temporal generalization gradients are again evident: *S*s were most likely to put a word in the correct list, and the tendency to use a given list category dropped off monotonically with temporal distance from the correct list. Second, *within* lists, the effect of manipulated context can be seen. Within the correct list *S*s tended to correctly assign words to B or E as before. However, in contrast to Experiment I, this tendency was also evident when the list was given incorrectly. Graphically, this fact is reflected in the tendency for the E curves of Figure 2 to have more positive slopes than the corresponding B curves. Excluding correct lists, the E slope is more positive in 11 of 12 such comparisons. Thus, even when a word was misplaced with regard to list membership, its within-list position tended to be correctly remembered.

The above observations were supported by the analysis of variance. Obtained frequencies were again corrected for individual *S*s' response biases, square-root transformed, and analyzed using planned comparisons. Judgment of list membership was significantly related to linear distance from the correct list, both when the correct list was included, F (1, 50) = 208.1, $p < .001$, and when it was excluded from the analysis, F (1, 50) = 87.9, $p < .001$. The effect of within-list position on the judgments was likewise significant, both when the correct list was included, F (1, 50) = 47.6, $p < .001$, and when it was excluded, F (1, 50) = 11.4, $p < .005$. This last comparison is evidence for the effect of within-list context. Using the .01 significance level, none of the four planned comparisons interacted significantly with test form, indicating that visual organization of the judgment scale was not an important determinant of *S*s' responses.

Experiment III

One outcome of both Experiment I and Experiment II which was contrary to expectations involves the symmetry in the way judgments were distributed over the temporal dimension. In Figure 2, where the phenomenon is most striking, the bottom two panels are virtually mirror images of the top two panels. In general, in both Figures 1 and 2, accuracy on words from the end of the last list was about equal to that on words from the beginning of List 1, and the extents of these primacy and recency effects were about the same. This symmetry of effects of primacy and recency on position judgments poses a problem for the contextual association hypothesis. In the reference experiment for the present studies (Hintzman & Block, 1971, Experiment I), the primacy effect was considerably greater than the recency effect, and it has been assumed here that the cognitive context changes most rapidly at the beginning of the experiment and more slowly thereafter. Thus, context should not change as rapidly during the final list as it did during the initial list—especially if *S* is unaware that the list is to be the last. The problem, then, is that the relatively large recency effects found in both Experiments I and II appear to be inconsistent with the assumption of a decreasing rate of overall change in context during the experimental session.

An analogy with free recall suggests itself. If a short delay is introduced, the recency effect in free recall disappears while the primacy effect does not (Glanzer & Cunitz, 1966; Postman & Phillips, 1965). The recency effect is therefore usually attributed to retrieval of the last items in the list from short-term memory. This explanation seems less appropriate for the present recency effect, which was obtained following a retention interval of more than 4 min. on the average—longer than short-term memory is usually assumed to span. Nevertheless, the analogy with free recall is still an interesting one. Accordingly, in Experiment III two groups of *S*s were run. Three lists of words were used, and one group was given the position-judgment test immediately following List 3, while the other group was tested after a 15-min. delay. The purpose was to determine whether primacy, recency, and within-list position effects would be affected differently by an increased retention interval. Differential forgetting of these cues would suggest different underlying mechanisms.

TABLE 2

RELATIVE FREQUENCIES OF USE OF RESPONSE CATEGORIES FOR OLD AND NEW WORDS, EXPERIMENT III

Words	Response category						
	1B	1E	2B	2E	3B	3E	New
Immediate							
Old	.11	.07	.16	.14	.20	.13	.19
New	.04	.07	.04	.02	.03	.01	.79
Delayed							
Old	.11	.07	.16	.13	.18	.15	.20
New	.03	.03	.05	.05	.02	.04	.78

Method

Materials. Experimental items were 129 three-letter nouns, 81 of which were assigned randomly to three lists of 27 words each. One recognition test sheet was constructed for each list, composed of a random ordering of the 13 words from the middle (Positions 8–20) of the list and 13 distractor words.

The test form for judgments of list membership and position was composed of the 7 words from the beginning (Positions 1–7) of each list, the 7 words from the end (Positions 20–27), and 8 new words. The test form differed from those of Experiments I and II in two ways: *S*s were given the opportunity to say that a word did not occur, and the format for the judgments was different. On the test form the 50 words were typed in a random order in two columns. Response alternatives, typed in a single row to the right of each word, were: the letter N in a column headed New; the numbers 1, 2, and 3, under the heading List; and the letters B and E, under the heading Part. The List and Part columns were in turn combined under the heading Old. The same test form was used for all *S*s.

Subjects and procedure. The *S*s were 90 paid volunteers, run in groups of up to 7 *S*s each. Groups of *S*s were randomly assigned to one of two experimental conditions: Immediate ($n = 42$) and Delayed ($n = 48$). Between sessions, the words were rotated through the 6 positions (3 Lists $\times$ 2 Parts); this was done by orthogonally varying both the ordinal position (1–3) assigned to a given word list and the direction of presentation of the list.

Instructions and procedure through presentation of List 3 were essentially the same as in Experiments I and II. About 3 min. separated the end of one list and the start of the next. Following presentation of List 3, *S*s in the Immediate condition were not given the List 3 recognition test, but were immediately read the position-judgment instructions and given the position-judgment test. The test began about 1.5 min. after the end of List 3, and *S*s proceeded through the test form at their own pace. The *S*s in the Delayed condition were first given the List 3 recognition test. This was followed by a memory-search filler task in which *S*s were to write down as many male first names as they could remember in an 8-min period. They then wrote descriptions of any search strategies they had used on the filler task. Finally, the instructions and test of memory for position were given. The total delay between the end of List 3 and the start of the position test was about 15 min. for the Delayed group.

The position-judgment test instructions were the same for both groups: *S*s were told to circle N if they thought a word was new, or if it was old to circle the number corresponding to the list in which it occurred and either B or E, depending on whether it had been closer to the beginning or end of that list.

Results

Table 2 presents the overall frequencies of use of the seven response categories. Unlike Experiments I and II, *S*s were here given the option of calling a word new. Thus, hit and false-alarm rates can be determined. For the Immediate condition they were .81 and .21, and for the Delayed condition they were .80 and .22, respectively. Not only are these figures very similar, but the two groups differed only slightly in their use of the six position categories. The delay apparently had only a slight effect, if any, on recognition performance and no obvious effect on response biases.

A posteriori probabilities were computed as in the previous experiments and are presented in Figure 3. The top three panels display the results of the Immediate group, the bottom three the results of the Delayed group. It is apparent from the figure that the major effects obtained in Experiment II, using four lists, were also obtained with three. Generalization along the temporal dimension is again obvious; and again the slopes of the broken lines tend to be more positive than those of the solid lines, indicating that words tended to be placed in the correct within-list positions, even when the list judgments were incorrect.

The planned comparisons, performed on the transformed data as in Experiment II, confirmed these observations. (For this analysis only, in order to accommodate the computer program, *n*s were equalized

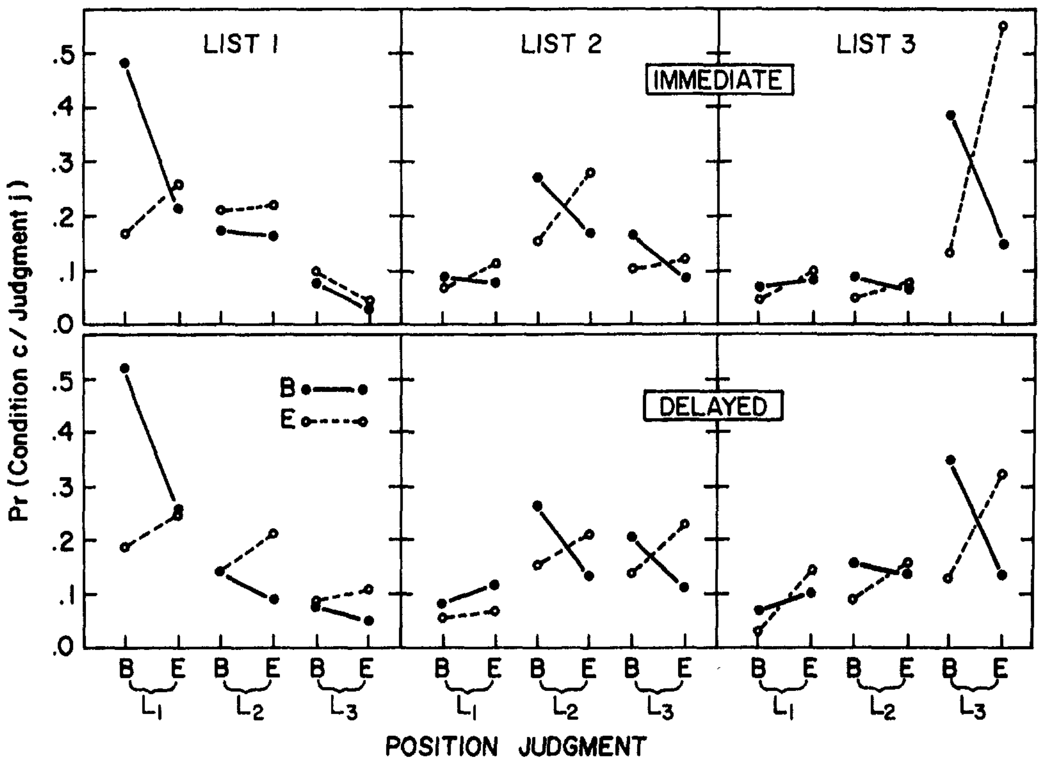

FIG. 3. Corrected response probabilities for Experiment III. (Top: Immediate test group; bottom: Delayed test group.)

by deleting data of six randomly chosen *S*s in the Delayed condition.) Judgment of list membership was linearly related to distance from the target list, both with the correct list included, F (1, 82) = 519.0, $p < .001$, and with it excluded, F (1, 82) = 111.7, $p < .001$. Likewise, within-list position was a contributing factor both when the correct list was included, F (1, 82) = 90.7, $p < .001$, and when it was not, F (1, 82) = 16.3, $p < .001$. Neither list nor position effects interacted significantly with groups, $p > .05$.

Although the interactions of list and position with groups were not significant in the routine planned comparisons, it is apparent from Figure 3 that the recency effect was greater with the Immediate than with the Delayed test. In general, the Delayed group was more likely to confuse Lists 2 and 3; however the most striking single contrast between the two conditions is the difference in accuracy on words from the end of List 3. This difference was reliable. The frequencies with which 3E words were correctly judged as 3E, adjusted for individual response biases and square-root transformed, differed significantly, t (88) = 3.27, $p < .01$. The superiority of the Immediate *S*s in this regard reinforces the earlier analogy with free-recall results—the recency component in memory for serial position, like that in free recall, apparently declines during a period filled with mental activity. The primacy and within-list position components do not. This conclusion assumes, of course, that the recognition test given the Delayed group did not affect performance on the final test. Since different words were used on the two tests, this seems to be a reasonable assumption.

DISCUSSION

The purpose of these experiments was to provide evidence for the role of contextual associations in memory for serial position, by showing that position judgments were affected by factors other than those strictly correlated with time. Experiments II and III provide that evidence by demonstrating that when *S* assigns a word to an incorrect list, there is nevertheless a tendency to place it in the correct within-list position. In addition, a temporal factor is indicated by the strong primacy effect and by the tendency for list identification to generalize more to adjacent than to nonadjacent lists. While these two factors may be due to quite different underlying mechanisms, the outcome of Experiment III, in which neither the within-list position factor nor the temporal factor was affected by the length of the retention interval, is consistent with the view that both effects are produced by essentially the same process. The recency effect, on the other hand, was affected by the retention interval, and may require a different explanation.

The theoretical reasoning behind these comments may be made more explicit as follows: Assume that when a word is presented and attended to by *S*, associations are formed between the meaning of the word and elements of the cognitive context prevailing at the time. Such elements may include implicit associations to the word or to other words in the list, mood states or attitudes, postural and physiological cues, and conspicuous external stimuli (cf. Anderson & Bower, 1972). Associations to some of these contextual elements serve as time tags, in the sense that they provide information that is correlated with the word's position in a series of events. When retrieved from memory during a retention test, these elements can therefore be used in judging the serial position in which the word originally occurred.

For present purposes, the set of contextual elements prevailing at a given moment can be thought of as consisting of three subsets: A, B, and C. The elements in A change in a regular fashion; their rate of change is a negatively accelerated function of time in the experimental situation, and they are relatively unaffected by list boundaries. Certain elements of A might be felt subjectively as "boredom." Subset A is needed to account for the primacy effect and the temporal generalization of list identification. The elements of B change in a regular way during presentation of a single list, but the original elements are reinstated whenever a new list is begun. Some of the elements of B might reflect momentary memory load, or "cognitive strain." Subset B thus accounts for the within-list position factor. Finally, Subset C consists of those contextual elements which are determined primarily by other variables and are therefore only haphazardly related to either time or within-list position.

The transitory recency effect constitutes a puzzle for the contextual explanation. One possibility is that contextual associations are not involved in the recency effect, as would be the case if, at relatively short delays, judgments of trace strength contributed additional recency information (Hinrichs, 1970). An alternative possibility, based on contextual cues, is that at short retention intervals *S* infers additional recency information from the degree to which elements associated with the word in memory match contextual elements prevailing during the test. Thus even elements of Subset C, although only haphazardly related to position, could provide temporary information concerning positions of fairly recent events.

This theoretical account, while somewhat sketchy, is in its essentials very similar to the theory of recognition memory recently advanced by Anderson and Bower (1972). Our generalization data are in accord with their view that list discrimination is based on retrieved contextual cues. The data are also consistent with their notion that the time tags which *S*s are apparently able to use to discriminate among traces of different repetitions of the same word (Hintzman & Block, 1971) are contextual in nature. A primary argument of Anderson and Bower is that familiarity would be an unreliable cue for recognition memory, which must therefore be mediated by other attributes. The demonstration that one can manipulate judgments of position by manipulating context adds needed support to their claim that the effective attributes are contextual associations.

One final point which deserves mention is that a contextual account of the nature of the time tag, although perhaps adequate to explain memory for serial position, may be of limited generality. Subjectively, it often seems that the age of a memory (e.g., days vs. months) is roughly known even though one is not aware of the judgment being based on contextual information. But more importantly, it can always be asked just how a person knew when a particular context occurred, and such a question can lead to an infinite regress. We have tried to avoid this logical difficulty here by suggesting that certain kinds of contextual elements, such as feelings of boredom and cognitive strain, might in themselves be sufficient to support logical inferences about time of presentation. It is by no means clear, however, that the information necessary for such reasoning is always available when the approximate age of a memory can be recalled.

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