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Inefficiency of Serial Knowledge for Associative Responding

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The organization of serial memory was examined. Subjects learned a serial list chunked into triplets, then learned a paired associate (PA) task in which the pairs were consecutive items from the original series. Those *S*s who were informed of the relationship between the tasks gave PA error patterns that corresponded more closely to the transition-shift probabilities of the serial task than did the PA error patterns of uninformed *S*s. Further, the informed *S*s showed positive transfer on early PA trials but negative transfer on the later trials, with overall learning rates averaging one-half to one-third of those of control *S*s. The effects of the instructions are interpreted as showing (*a*) that *S*s have multiple PA strategies available, and (*b*) that serial-recall memory may not always include direct links between consecutive items.

This paper examines once again what it is that an *S* knows after he has learned a serial list. The predominant view is that serial learning and recall can be represented theoretically in terms of S-R associations, although several exceptions to this formulation should be noted (e.g., Battig, Brown, & Schild, 1964; Jensen, 1962; McLean & Gregg, 1967). Within this S-R context, another debate focuses on the "functional stimuli" to which the serial responses are associated—the "position" hypothesis versus the traditional "chaining" hypothesis. Proponents of either hypothesis agree, however, that transfer in either direction between serial-list learning and a related paired-associate (PA) list provides relevant data for distinguishing the hypotheses, and such experiments have been treated in recent reviews (e.g., Jensen & Rohwer, 1965; Young, 1968). The extreme hypotheses usually suppose that *S* can learn the serial list in only one way; the hypotheses disagree on what that way is, but they agree on the general assumption that simple associations will suffice to characterize what is learned.

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Jensen (1962) has questioned the adequacy of S-R association theory as an explanation of serial learning and has proposed an alternative. He views the learning of a sequence for serial recall as a process of response integration—learning to say or write a sequence of words. Serial learning might then be regarded as the formation of a plan for generating a series of items (cf. Miller, Galanter, & Pribram, 1960). This description appears especially appropriate when the list is to be recited all at once ("serial recall") as opposed to giving the next successor to each cue word in turn ("serial anticipation"). Possibly the serial recall versus serial anticipation methods lead *S* to adopt different knowledge structures, and these in turn could produce differing degrees of transfer to a derived PA task. For example, serial recall may be viewed as unpaced "free recall" with an added serial constraint on output, whereas serial anticipation shares more the features of a serially constrained PA task. On this basis, one might expect more PA transfer after serial anticipation learning than after serial recall learning. The present experiments use the serial recall method and attempt to manipulate by instructions the degree of transfer to the derived PA task.

The main variable to be studied is whether or not *S* is instructed regarding the relationship between the serial and PA tasks. If there were but a single learning process by which serial lists were acquired, and a singular, automatic manner of application of that knowledge to the PA task, then instructions could not possibly alter the degree of serial-to-PA transfer. In effect, that is the viewpoint implicit in the strict "chaining" or "position" hypothesis regarding serial learning. But it is intuitively unlikely that instructions are irrelevant and immaterial to transfer performance. It is rather more likely that *S*s have several learning strategies available—that they select a strategy for learning or recalling depending in part upon their knowledge regarding the nature of the learning task. In particular, performance and learning of the PA transfer task might be attacked quite differently depending on whether *S* recognizes the relationship of the PA list to the prior serial list. So the present experiments will inform some *S*s but not others of the relationship between the serial and PA tasks.

A few prior studies have manipulated instructions in the serial-to-PA transfer situation (e.g., Jensen & Rohwer, 1965; Postman & Stark, 1967), and these findings will be discussed later. The present experiment goes beyond the previous ones in providing an analytic tool for tracking in the PA transfer task the effect of knowing and using the prior serial list. The analytic tool is the difference in PA performance between pairs that served varying roles in the prior serial list. During learning, the serial list is physically grouped into triad chunks having the paradigmatic form (ABC) (DEF) (GHI). . . . Such groups tend to be learned as all-or-none units, so that recall of adjacent elements within a group shows higher interdependencies than does recall of adjacent elements belonging to different groups (cf. Bower & Springston, 1970; Johnson, 1968). Stated differently, the empirical probability of recalling Item $n+1$ given recall of Item n is higher when both items fall within one group (e.g., A-B, B-C, D-E) rather than in separate groups (e.g., C-D, F-G). If this is true, and if *S* uses his serial knowledge-structure for performing the PA transfer task, then he should make many more errors on the between-group pairs than on the within-group pairs. Alternatively, if *S* does not apply his prior serial knowledge to the PA transfer task, then there should be no difference in transfer on the within- versus between-group pairs. Therefore, a comparison of transfer errors on within- versus between-group pairs provides an index of the extent to which *S* is using his prior serial-list knowledge to carry out the PA transfer task.

The present experiments compare performance of instructed and uninstructed *S*s on transfer to within- versus between-group pairs. The two experiments are similar, differing only in the materials used—letters in Expt. I, words in Expt. II—with a different control group included in Expt. II to answer a question raised by the results of Expt. I.

Experiment 1

Method

Design. Two groups of *S*s learned a serial list and then a derived PA list. One group (I, for Instructed) was told how the PA list was derived from the prior serial list; the second group (U, for Uninstructed) was not told of this relation. A third group (C, for Control) simply learned the PA list without any prior training.

Material and procedure. The serial list was 15 consonant letters long, chunked by temporal groupings into triplets. Three different subsets of 15 consonants (excluding W) were used, each with a third of the *S*s in each group. The serial list was presented visually, each triplet separately, in left-to-right order, for 4 sec, by an *MTA Scholar* teaching machine. After each presentation, *S* had up to 2 min, if needed, to recall orally the 15 consonants in their presented order. Such study-recall cycles continued until *S* achieved two consecutive errorless recitations of the list. The PA transfer task then began for Groups I and U.

The PA list was composed of 12 of the 14 possible adjacent letter pairs from the prior 15-item serial list. Not used were one pairing from the first to the second element of one triplet, and one pairing from the second to the third element of another triplet (the positions of the specific deletions varied across *S*s). The letter pairs occurred in a new random order for each of 10 trials, with learning and oral recall tested by the anticipation method at a 3:3-sec rate with a 3 sec III. A "guess" was requested on Trial 1 even before the correct pairings were seen.

After learning the serial list and before doing the PA task, the *S*s in Group I were thoroughly instructed concerning the derivation of the PA list they were about to learn. The *S*s in Group U were transferred to the PA list without being informed of its derivation. The *S*s in Group C received only the PA portion of the experiment. Twelve *S*s, 6 men and 6 women, were assigned to each condition. They were solicited by a newspaper advertisement, had education beyond a high-school diploma, and were paid for their services.

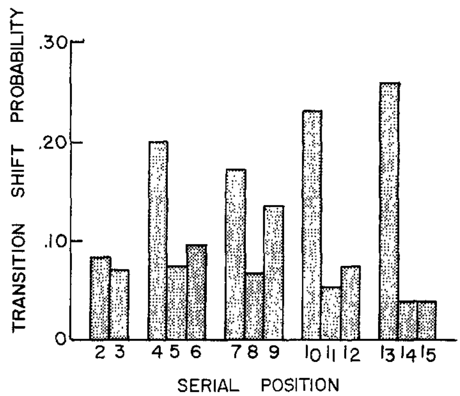

FIG. 1. Transition shift probabilities for the serial task (Expt. 1).

Results

Serial learning. The average number of trials to criterion were identically 6.2 for both Groups I and U. The serial list was physically chunked into triplets to induce differing degrees of connections between adjacent letters in different positions of the series. A graphic profile of the varying degrees of adjacent letter-to-letter associations across the series is provided by transition-shift probabilities (TSP) computed on the serial recall protocols. The TSP at Position *n* in the series is the probability that a run of recalls or nonrecalls breaks off between Elements *n*-1 and *n*. In other words, the TSP is the joint probability of either recall-nonrecall or nonrecall-recall of Elements *n*-1 and *n* (cf. Bower & Springston, 1970). If the triplets are being recalled as unitized chunks, then there should be high TSP values on the first element of each triplet, with lower TSPs on the second and third elements of the triplet.

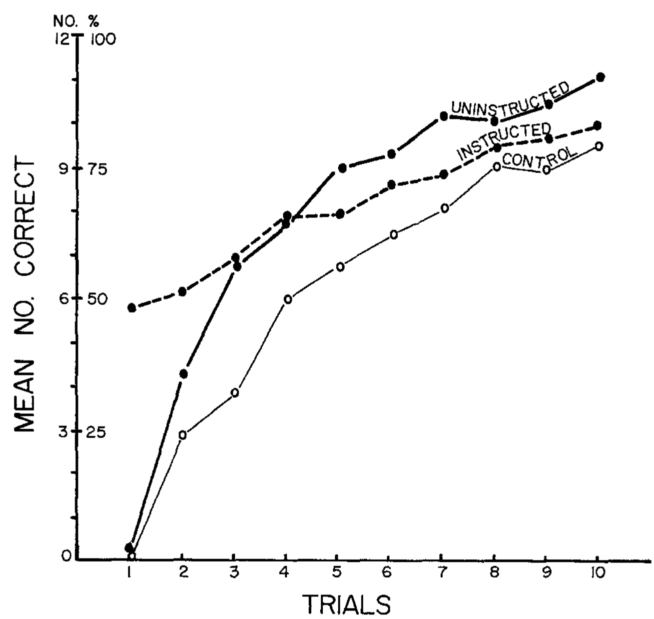

FIG. 2. Learning curves for the paired-associate task (Expt. 1).

The relevant data are shown in Figure 1, obtained by pooling and classifying all n-1 to n transitions in all recalls before criterion for *S*s in Groups I and U. No TSP can be calculated for Position 1. The main impression to be gathered from Figure 1 is its saw-toothed appearance; within each triplet, the first element has the largest TSP. This pattern was expected, and it had to be demonstrated in the serial task before one could use a similar error profile in the later PA transfer to infer the specific influence of the prior serial task.

Paired associate transfer. The main effects of the experimental treatments are shown in Figure 2, which depicts the proportion of correct responses over trials on the PA transfer task. The most obvious feature is that Instructed *S*s commence the PA task performing considerably better than the Uninstructed *S*s, but that the Uninstructed *S*s improve much more rapidly than do the Instructed Ss. The result is a cross-over of Uninstructed and Instructed *S*s such that Instructed *S*s show initial "positive" but eventual "negative" transfer with respect to the Uninstructed *S*s.

Statistics substantiate the above claims. On Trial 1, Group I was the only group to perform significantly above zero ($t(11) = 12.01$, $p < .001$). By Trial 10, performance by Groups U, I, and C fell in the order 93, 83, and 77%, respectively. Group U was significantly above the other two groups, $F(1, 33) = 5.06, p < .05$. Learning rates may be compared more formally using a mathematical description of the learning curve (cf. discussion by Bower & Lesgold, 1969). The learning rate, θ, is computed for each S by fitting to his PA data the formula

$$p_n = 1 - (1 - p_1)(1 - \theta)^{n-1},$$

where p_n is the proportion of correct responses on Trial n and p_1 is the proportion correct on Trial 1. This equation permits one to separate the learning rate, θ, from the initial starting level of performance, p_1. The average θ estimates obtained in this way were .36, .17, and .22 for Groups U, I, and C, respectively. These differ reliably, $F(2, 33) = 5.09, p < .025$. By the Newman–Keuls procedure, the learning rate for Group U was significantly above the other two which did not differ reliably. The significant fact to be emphasized here is that Uninstructed *S*s learned at a rate more than twice that of the fully Instructed *S*s.

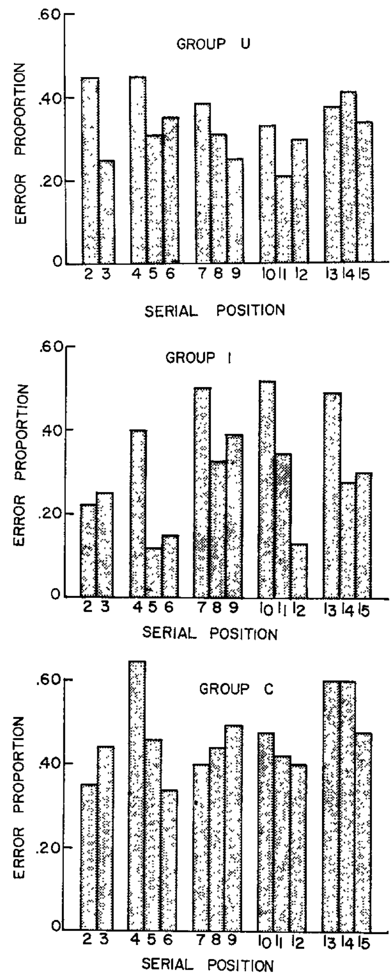

FIG. 3. (*Top*) Error proportions by serial position for Uninstructed *S*s in paired-associate task. (*Middle*) Instructed *S*s. (*Lower*) Control group (Expt. 1).

PA error profiles. The next question is whether variations in interletter associations induced by serial chunking (cf. Figure 1) were revealed in errors made during PA transfer. The proportions of errors over the

10 PA trials for pairs deriving from different serial positions are shown in the three panels of Figure 3 for Groups U, I, and C, respectively. The overall patterns of peaks and troughs should be noted and compared to those in Figure 1. The variations of values in Group C (Figure 3, lower panel) presumably represent chance fluctuations since those *S*s had no prior serial list. Importantly, the profile of error rates for Group I (middle panel) shows a striking correspondence to the "high-low-low" pattern of TSP within triplets of the serial task (cf. Figure 1), whereas this pattern appears much less pronounced for Group U (top panel). The magnitude of this high-low-low patterning can be indexed by the ratio of the proportion of errors on between-chunk pairs to the proportion of errors on the within-chunk pairs. This ratio exceeds 1 to the extent that between-chunk pairs are more difficult than within-chunk pairs. On this index, computed for each *S* before averaging, Groups I, U, and C averaged 2.58, 1.27, and 1.22, respectively. These indices differ significantly, $F(2, 33) = 9.84$, $p < .01$; this is clearly due to Group I exceeding Groups U and C on this index, whereas the latter two do not differ from one another (nor from the "chance" or null-difference ratio of 1.00).

To summarize this section, then, the transfer errors made on pairs derived from different parts of the serial list were closely related to the TSP profile of serial learning if *S*s were told how the PA list was derived; but no correlation between PA errors and TSP profile occurred when *S*s were not informed of the derivation of the PA list. Moreover, it was the instructed *S*s, showing the correlation between TSP and PA errors, who also showed strong negative transfer in their rate of learning the PA task. It thus appears that when *S* most seems to be utilizing his serial knowledge-structure for responding to the PA task, he is at the same time learning only very slowly how better to cope with the requirements of the PA task.

The remarks above suggest that *S*s in the Uninstructed condition either did not "notice" the relationship between the PA and serial lists, or they noticed but did not make any use of the relationship to generate their PA performance. Of relevance to this issue are the answers to a questionnaire given orally to *S*s in Group U at the completion of the experiment. The questions probed, with increasing specificity and hints, for *S* to relate anything he had noticed concerning the serial and PA lists. Only 2 of the 12 *S*s were able to specify the derived nature of the PA list. Six of the 12 *S*s reported noticing no relationship whatsoever, whereas 4 *S*s indicated varying degrees of partial knowledge (e.g., that some of the same letters were involved in the two lists, or that occasional pairs were adjacent letters in the serial list). From such interview data, it is clear that most uninstructed *S*s do not notice, infer, or become aware of the precise derivation of the PA list from the serial list, nor do they appear consciously to use their knowledge of the serial list to compose their responses to the PA task. On the other hand, instructed *S*s do appear to use their serial knowledge-structure in responding to the PA task; it helps them in the beginning, but it is inefficient and sluggish in the long run.

The conclusions so far are that Group I shows initial positive but eventual negative transfer with respect to Group U. Figure 2 shows that both groups outperformed the Control group which learned the PA without prior learning of any serial list. The mean number of correct responses over the 10 trials per item per *S* was 6.8, 6.6, and 5.2 for Groups I, U, and C, respectively. The Group-C mean is significantly below the other two means, $F(2, 33) = 36.7$, $p < .01$. So with respect to this type of control, both Groups I and U show "positive" transfer. However, the relations among learning rates and awareness for Groups I and U suggest that their overall superiority to Group C is, in this instance, a general practice or warm-up effect, and it is probably not specific to the particular serial list learned before the PA list. An alternative control would be to have *S*s learn a serial list before the PA list, but have the serial and PA lists contain totally different items. The PA performance of these *S*s should benefit from any general practice or warm-up effect, but their performance could not be influenced by the associations acquired to specific serial items. A control group of this type was included in Expt. 2. Also, words instead of consonant letters were used as items in an attempt to achieve some systematic replication of the conclusions from Expt. 1.

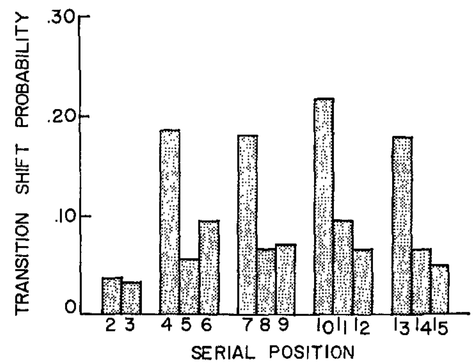

FIG. 4. Transition shift probabilities for the serial task (Expt. 2).

EXPERIMENT 2

Method

With the following exceptions, this experiment was identical to the first. The items were nouns of AA frequency, selected from the list of Paivio, Yuille, and Madigan (1968). Three separate lists were prepared, each with entirely different words. Each list was given to a third of the *S*s in each group. The procedure was the same as in Expt. 1, except that the new Group C now received an initial serial learning task. Each *S* in Group C received one of the two serial lists other than the one from which his PA list was derived. All list choices were counter-balanced over *S*s across conditions.

Results

Serial learning. The three groups did not differ in speed of initial serial learning; the mean trials to criterion for Groups U, I, and C, respectively, were 5.7, 6.5, and 6.9, $F(2, 33) = 1.94, p > .10$. Figure 4 shows the TSP scores for the pooled data. As before, the first member of each triplet shows a higher TSP than

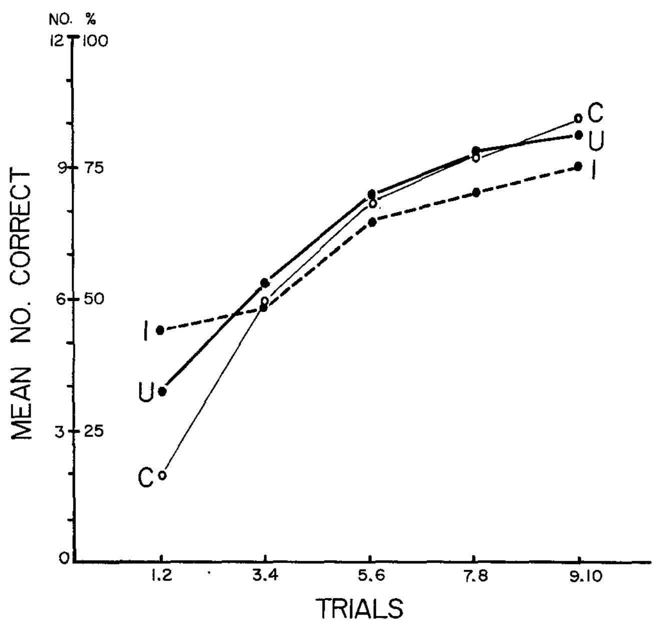

FIG. 5. Learning curves for the paired-associate task (Expt. 2).

does its second or third members, confirming the adequacy of the grouping manipulation.

PA learning. The learning curves for the three conditions are shown in Figure 5; they are quite similar to those in Expt. 1 (Figure 2) except for the location of the new control group. Recall on the first "guessing" trial was 43, 21, and 0% for Groups I, U, and C, respectively. The initial percentage correct for Group I significantly exceeded those of Groups U or C ($p < .05$). Groups U and C improved their performance over trials faster than did Group I, crossing over and surpassing Group I. By Trial 10, Groups U and C had a 10% advantage over Group I. Learning rates (θ) were estimated for each *S* using the method outlined previously. The average θ estimates for Groups U and C were each .27 which may be compared to a θ estimate of .12 for Group I. Thus, learning rates for control and uninstructed *S*s were more than double those for instructed *S*s, $F(1, 33) = 8.78, p < .01$. So with respect to the ancillary question raised at the end of Expt. 1, one may claim that *S*s in Group I show "negative transfer" in learning rate with respect to a suitable "warm-up" control group.

One could come to entirely different conclusions regarding transfer in this experiment if only a summary performance measure were examined. For instance, the mean numbers of correct responses per item per *S* over the 10 PA trials were 6.07, 6.33, and 5.90 for Groups I, U, and C, and these do not differ significantly, $F(2, 33) = .34, p > .05$. Thus, while such a summary measure suggests no transfer effect whatsoever of the prior serial training, the complete learning curves in Figure 5 suggest a more interesting conclusion.

Error profiles. As in Expt. 1, interest focuses on how much transfer occurred on a pair in relation to its former serial position. The three panels of Figure 6 show the proportion of errors (over 10 PA trials) for items deriving from differing serial positions for Groups U, I, and C, respectively. These error profiles should be compared to the TSP profile in Figure 4 for the original serial learning. In such comparisons, it is clear that the PA error profile for Group I (Figure 6, middle panel) bears a close resemblance to the serial TSP profile, with the "high-low-low" pattern apparent in each triplet grouping. The PA

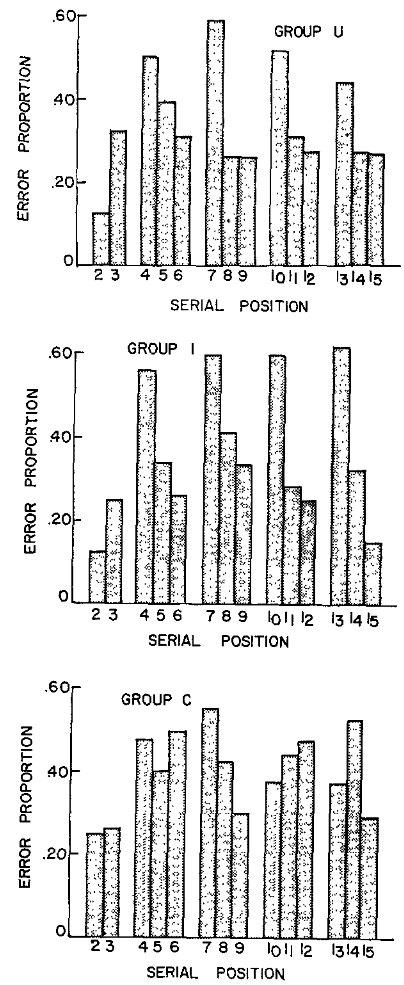

FIG. 6. (*Top*) Error proportions by serial position for Uninstructed *S*s in paired-associate task. (*Middle*) Instructed *S*s. (*Lower*) Control group (Expt. 2).

error profile of Group U (upper panel) shows a definite resemblance to the serial TSP profile though less marked than that of Group I. The "high-low-low" sawtooth error pattern is, of course, totally absent for the control *S*s (lower panel). The magnitude of the "high-low-low" pattern in the three panels was indexed as before by the ratio of errors on the between-chunk pairs to the average errors on the within-chunk pairs. This ratio, computed for each *S*, then averaged, was 2.71 for Group I, 1.88 for Group U, and 1.16 for Group C. The statistical contrast between Group I versus Groups U and C was significant, $F(1, 33) = 8.68$, $p < .01$, but the residual variation was not, $F(1, 33) = 2.41$, $p > .05$.

Discussion

Experiment 2 replicated the essential features of Expt. 1, namely, initial positive followed by negative transfer for *S*s instructed regarding the interlist relations. Presumably instructed *S*s use their serial knowledge to generate many correct guesses on transfer Trial 1, whereas uninstructed *S*s make only a few correct guesses and the controls practically none. Uninstructed *S*s initially exceed chance performance presumably because some of them notice that some of the pairs were adjacent serial elements, and they apply this strategy in producing guesses. It seems plausible that uninstructed *S*s would notice the interlist relations more often with words than with consonant letters; in line with this, initial correct guesses averaged 21% in Expt. 2 with words compared to 2% in Expt. 1 with letters.

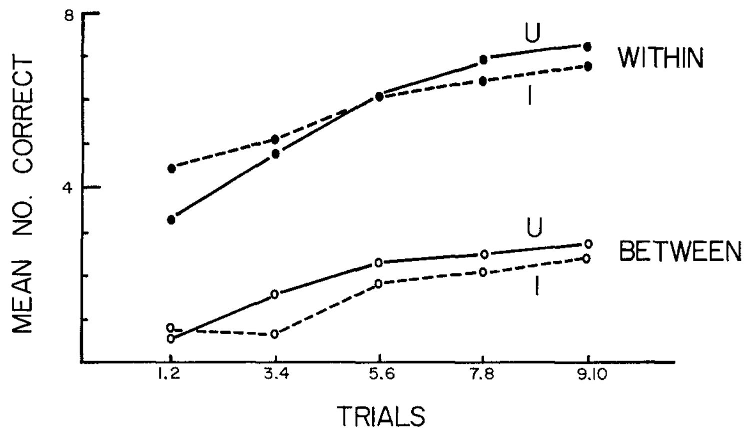

FIG. 7. Learning curves for within-chunk and between-chunk pairs in Uninstructed and Instructed conditions (see text).

Since *S*s in Group I made more errors on between-chunk pairs than on within-chunk pairs, it is natural to ask whether the "cross-over" and negative transfer seen in Figure 5 were due only to between-chunk pairs. This query is answered by the results in Figure 7 which graphs for Groups I and U the mean numbers of correct responses over trials on the eight within-chunk pairs and on the four between-chunk pairs. It is clear that the "cross-over" of I and U learning curves occurs for both within-chunk and between-chunk pairs. So the instructed *S*s learned slower than uninstructed *S*s on both types of pairs.

Figures 2 and 5 show substantial initial positive PA transfer by instructed *S*s in comparison to either control group. Such initial positive transfer has been reported frequently before, especially when *S*s were informed of the interlist relations (e.g., Jensen & Rohwer, 1965; Postman & Stark, 1967; Shuell &

Keppel, 1967). The large reduction in PA learning rate for instructed experimental vs. control *S*s has not been noted before, apparently because the relevant analyses were not done or at least were not reported. Jensen and Rohwer (1965) noted a change from positive to negative transfer by experimental *S*s in reaching successive thirds of criteria toward mastery of the PA transfer list. However, that result seems to have been overlooked in subsequent work. It is possible, too, that our result, of negative transfer in learning rate, was not observed previously because it may arise from the serial recall as opposed to the serial anticipation procedure, and the anticipation procedure has been used almost exclusively in prior transfer experiments.

The difference in PA performance between instructed and uninstructed *S*s indicates alternative transfer or learning strategies available to *S*, with the strategy adopted being influenced by instructions. Our current view is that instructed *S*s try to use their serial association network to construct answers for the derived PA task, whereas uninstructed *S*s either never use their serial knowledge or begin using it somewhat but soon abandon it because of its inefficiency for the PA task. This suggests that several factors control whether *S* brings specific past information in memory to bear upon a new learning task. One might call this effect the "cognitive control of transfer."

It was claimed that instructed *S*s apply their serial knowledge to the PA task whereas uninstructed *S*s, by and large, do not. The chief evidence for these statements is the similarity of the PA error profiles to the TSP profiles for serial learning. For Group I, the similarity is quite high; for Group U (in Expt. 1, especially), it is very low. Stated in different terms, informed *S*s show better PA performance on those pairs reflecting the stronger serial associations. This type of correlation has been observed before by Shuell and Keppel (1967), where it was specifically not confounded with the position of the pair in the serial list (their serial list had a variable starting point).

We have suggested that instructed *S*s use their serial association structure to perform the PA task and that this is partially successful. However, that strategy is not only inefficient in the long run, but it also retards *S*'s adoption of a more efficient set of associations tailored for the PA task. The question may still be raised as to why it is that the serial association network, which is sufficient to support the recall chain of saying item n after saying item n-1, is not sufficient to the task of saying item n after seeing item n-1. Possibly an explanation may be found by elaboration of Jensen's earlier (1962) hypothesis that serial recall involves production of an integrated chain.

Instead of supposing that serial knowledge is represented as a listing of discrete (n-1)-to-n associations or as a chain of associations, it may prove more viable in some instances to let a *hierarchical graph* structure serve as the representation. That is, *S*'s knowledge of the serial list would consist of a set of "chunks," where chunks are defined recursively either as sequences of lower-order chunks or as sequences of terminal (response) symbols (cf. Johnson, 1968; Miller, Galanter, & Pribram, 1960). A hierarchical graph structure contains links (associations) not only between individual items but also between chunks. Figure 8 illustrates the hypothetical hierarchical structure of associations existing after *S* has learned the three-chunk list (ABC) (DEF) (GHI). The top chunk, LIST, decodes

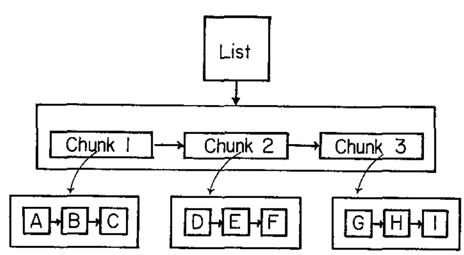

FIG. 8. Hierarchical graph structure for the chunked sequence, *ABC DEF GHI.*

into three chunk codes, each one of which decodes into a subchain of items. Johnson (1968) and Wilkes and Kennedy (1969) have suggested specific rules and mechanisms for behavioral decoding of such information structures. An implication of these theories is that adjacent elements falling within a chunk (e.g., B-C) are connected more closely than are adjacent elements spanning two chunks (C-D). This implication is the motivation for, and is uniformly supported by, TSP profiles for recall of a chunked series. Such hierarchical chunk structures have also been proposed as models for the organization in free recall protocols (cf. Bower, Clark, Lesgold, & Winzenz, 1969; Mandler, 1968; Tulving, 1962). In free recall of words, the chunks usually correspond to more or less definite semantic categories and the links between chunks or between words are nondirectional since a specific output order is not required. Serial recall, having a constraint on output order, differs in requiring directional linkages.

Supposing *S*'s serial knowledge were to be represented by a graph structure like that in Fig. 8, what might be expected when this structure is used for deriving answers to the PA transfer task? One would expect more errors on between-chunk pairs than on within-chunk pairs, and our instructed *S*s clearly showed this. This result is also related to one by Wilkes and Kennedy 1970 showing relatively longer reaction times for *S* to report the item after a probe item which was located just before versus just after a chunk boundary. Since the PA transfer task was paced, *S*s may not have had sufficient time to retrieve the "response" item n from the "stimulus" item n-1.

More generally, an important distinction can be made between the appearance of an item as a stimulus and the appearance of that item as part of an integrated response. There is no strong reason to suppose that the connection in *S*'s memory between the tokens for responses n-1 and n of the series is in any way identical to a link between the representation of item n-1 as a stimulus (type) and that of item n as a response (token). The serial R-R link is a token-to-token link, while the S-R link in the derived PA list is of the type-to-token variety (cf. Quillian, 1965). For example, although *S* may know how to read or produce a list of integrated word-spelling chains, a specific fragment of the word (especially its middle part) may not be recognized as seen before (Tulving & Osler, 1967), nor will it lead to very high recall of the next segment or of the whole word (Horowitz, White, & Atwood, 1968).

Suppose that the serial recall structure involved only token-to-token links, whereas the optimal organization of knowledge for the PA task is a list of stimulus-response, type-to-token linkages. If this were true, then use of the serial information structure is doomed to have minimal success because individual items are unlikely to be "functional" stimuli. Rather, *S* can get the response only indirectly, by silently reciting the series or a fair portion of it, and saying aloud the item after the stimulus item in his recitation. This takes time and will often fail; but its partial success prevents *S* from scrapping the serial strategy and retards the beginning of his serious efforts to learn the type-to-token associations needed for the PA task. In this respect, the negative transfer observed in serial-to-PA tasks is remarkably similar to that found in part-to-whole list transfer in free recall of unrelated words (cf. Bower & Lesgold, 1969; Tulving, 1966). In free recall, teaching *S* a part of a list retards his later learning of the whole list, presumably because a subjective organization (or chunk structure) suggested by the part list is persistently used by *S* with the whole list, although that organization is nonoptimal for the whole list of items. The part learners recall much more than appropriate control *S*s initially, but their subsequent learning is much reduced, resulting in a cross-over of the learning curves, much like those depicted in Figures 2 and 5. In either case, whether the part-to-whole or the serial-to-PA task, one may describe the negative transfer in learning rate as resulting from *S*'s persistence in trying to get along with an inefficient organization of the relevant information. In these cases, "a little knowledge is a dangerous thing."

The Uninstructed *S*, on the other hand, begins the PA task trying to learn simple stimulus-response associations. Even if he notices that the pairs derive from the prior series, a few quick trials should convince him that the series information is not in usable or easily accessible form for the PA task. Hence, the best the Uninstructed *S* can do is to ignore the series, thereby behaving like the Control *S*s who have no series information to interact with their new learning. For these Control *S*s, it is truly the case that "what they don't know won't hurt them."

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