Rehearsal and free recall in children of superior and average intelligence*

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Children of similar chronological age who were either of superior or average intelligence were presented with lists of common words for single-trial free recall. Rehearsal was recorded during list presentation. Children of superior intelligence exhibited greater recall and rehearsal. This superiority in performance, however, was limited to the initial and middle portions of the serial position curve. Recall and rehearsal at terminal serial positions did not differentiate the groups. The results were interpreted as supporting a two-process view of immediate recall used to elucidate memory disparities between normal and retarded adolescents.

The available evidence indicates that children of lower intelligence are inferior in immediate memory when compared to more intelligent children of similar chronological age (Belmont & Butterfield, 1969). Ellis (1970) has proposed a theoretical scheme to account for differences in immediate recall between groups of similar chronological age but disparate intelligence. Following the lead provided by Waugh & Norman (1965) and Atkinson & Shiffrin (1968), Ellis assumes that immediate recall is composed of items drawn from a primary and secondary memory store. Empirically, when frequency of recall is plotted against the serial position of the item in the message, the resulting serial-position curves are usually bow-shaped, with the greatest recall occurring at initial and terminal serial positions. Theoretically, the strength of the terminal portion of the serial-position curve is determined by the contents of the primary memory store, while the items in secondary memory contribute to recall at the initial and middle sections of the serial-position curve. With regard to differences due to intelligence in immediate recall, Ellis suggests that less intelligent children are deficient in secondary memory only. The less intelligent child's primary memory is assumed to be comparable to that of the more intelligent child. Operationally, the Ellis formulation predicts that superiority due to intelligence level in immediate recall is to be found in the initial and middle

portions of the serial-position curve and would predict no differences between groups on the recall of terminally presented items. Empirical support for such predictions has been presented by Ellis in experiments comparing normal and retarded adolescents on the immediate recall of serial position information. Specifically, the experimental paradigm employed by Ellis involves comparisons of college students with institutionalized young adult retardates. Their task is to press a key indicating the correct position in which one of a series of stimuli appeared.

A recent study by Fagan & Binzley (1970) explored the generality, with regard to task and S variables, of the theoretical scheme proposed by Ellis. In an initial experiment, the multitrial free recall performance of average (100 IQ) and retarded (75 IQ) adolescents was compared. A second observation employed a multitrial free recall task with superior (130 IQ) and average (100 IQ) children. The pertinent results of each comparison made by Fagan and Binzley, average vs retarded IQ and superior vs average IQ, may be summarized as follows. In each instance, the higher-IQ sample exhibited the greatest recall. This superiority in recall, however, occurred only over the initial and middle portions of the serial position curve. Recall at terminal serial positions was equivalent for groups of differing IQ. The Fagan and Binzley findings support the two-process view of immediate recall used by Ellis to identify sources of memory disparities between children of different IQ levels. Specifically, their results also indicate that superior- and average-IQ children on a free recall task will show the same kinds of differences that the normal and retarded adolescents in the Ellis studies exhibit on tasks involving immediate recall of serial order information.

To recapitulate, it appears that the

immediate recall deficit of lower-IQ children is to be found in the secondary memory (SM) rather than in the primary memory (PM) component of immediate memory. Given such a theoretical state of affairs, the mechanism that allows information to be transferred from PM to SM during the acquisition of a list of items becomes of crucial importance in determining the nature of the lower-IQ child's SM deficit. According to Ellis and other investigators (e.g., Atkinson & Shiffrin, 1968; Rundus & Atkinson, 1970), the important mechanism in this regard is the rehearsal strategy, since they hypothesize that it is rehearsal that allows one to transfer items from the temporary PM store to the more stable SM store. It would seem, then, that the most fruitful future approach to the study of IQ-related deficits in immediate memory would lie in the examination of rehearsal strategies. Belmont & Butterfield (1971), for example, have shown that the recall of serial order information in a probe task can be related to the patterns of pauses that Ss exhibit during S-paced presentation of a list of items. More germane to the purposes of the present study is the procedure developed by Rundus & Atkinson (1970), using college students, for the observation of rehearsal strategies in free recall. The Rundus and Atkinson approach involves presentation of a series of different lists for free recall, each list given a single trial. Each item in a list is shown for a set study period, and the S is instructed to rehearse out loud that item (if he chooses) and any other list item he wishes during the study period. No restrictions are placed on the choice of items to be rehearsed or on rate of rehearsal. A tape recording is made of rehearsal on every trial. Following the study period for the last list item, the S recalls as many of the list items as possible. A rehearsal protocol for an individual S is reduced to a number of "rehearsal sets" (RS). An RS is defined as all the rehearsals occurring during a particular study period. RS data has allowed Rundus and Atkinson to show that the amount of rehearsal is related to the form of the serial position effect. Presumably, the examination of the material contained in children's rehearsal sets would lead to a better understanding of the nature of IQ-related deficits in secondary memory. Therefore, the aim of the present study was to explore the nature of IQ-related deficits in immediate memory by comparing rehearsal and recall behaviors of superior- and average-IQ children on a free recall task, specifically, by relating obtained rehearsal strategies to serial position effects in recall.

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Fig. 1. Mean number of items recalled over six lists and mean number of rehearsals over six lists as a function of serial position for children of superior intelligence (S) and average intelligence (A).

SUBJECTS

The sample consisted of 56 children, 28 in each of the two IQ groups. All were drawn from classes in two suburban parochial school systems. The mean CA of the superior-IQ group (S) was 10.7 years, SD .5. Their mean IQ was 128.0, SD 8.3. The mean CA of the average-IQ sample (A) was 10.6 years, SD .4. Their mean IQ was 95.8, SD 6.1. The groups were approximately balanced for sex, with 14 males and 14 females in Group S and 16 males and 12 females in Group A.

DESIGN

There were two IQ groupings: 28 S and 28 A. The task consisted of orally presented sequences of common nouns requiring oral short-term recall. Each S was given one free recall trial on each of six different 10-item lists. Lists were constructed by selecting 60 common words from existing free-association norms for children (Palermo & Jenkins, 1964) and deriving six 10-item lists with the restriction that words within and between lists be of low interitem associative strength. All Ss received the same six lists in the same sequence.

PROCEDURE

The Ss were tested individually in a quiet room by a female assistant. All Ss were given two test sessions with a 1-week separation between tests. Each session included three of the six lists. The equipment consisted of two Voice of Music, Model 734, tape recorders, one for list presentation and one to record Ss' responses. From a prepared

tape, S heard the word "ready," followed 5 sec later by the first word in the list. The words were presented at the rate of one every 5 sec. The word "now" followed the last word in the list by 5 sec. The S's task was to "say whatever words" he was "thinking about" during the 5-sec period following each list item and to recall the words when he heard "now." Following the "now" signal on each list, recall was S-paced and was usually accomplished within 30 sec. A 3-min period between lists was filled with a recognition memory task for photos of faces, irrelevant for our present purposes and given only to demark each word list as a distinct event for the child.

Prior to the first session, S was told, "This is a game to see how well people remember. I am going to say, 'Ready,' and then some numbers. When you hear me say, 'Now,' you tell me what the numbers were. You can remember the numbers any way you want to." A list of six numbers was then read to S. After his recall, E continued, "Very good. Usually when people try to remember things they say them to themselves in their heads. Were you doing that?" The child would invariably answer, "Yes." "I am going to say six more numbers and instead of saying them to yourself say them out loud. Say all the ones you are thinking about and trying to remember." A second list of six numbers was then presented. "Now we are going to do the same thing with words. On this tape you will hear a list of 10 words. After you hear each

word, say out loud all the words you are thinking about and trying to remember. When you hear 'now' say all the words that you remember." The appropriate instructions were repeated to S prior to the second session. The words "ready" and "now" and the words in each message were recorded by a female assistant at approximately the same loudness. At the beginning of each session, the volume at which the tape was to be played was adjusted to a comfortable level for each S and was maintained at that level throughout the session. A typical session lasted about 15 min.

RESULTS AND DISCUSSION

The major objectives in statistical analyses were to determine the effects of IQ on recall and on rehearsal. Assuming that the Ellis theory may be generalized to include comparisons of average- and superior-intelligence children and based on the findings of Fagan and Binzley, it was expected that advantages in recall due to superior intelligence should be confined to the initial and middle portions of the serial position curve. If transfer from primary to secondary memory is dependent upon rehearsal, it was also expected that children of superior intelligence would exhibit greater rehearsal than children of average intelligence, particularly for items occurring in the initial and middle sections of the serial position curve.

For each S there were six recall scores, one for each list. From these measures, the groups' mean recall score was derived, over lists, for each input serial position. These mean group scores are illustrated in the left-hand graph in Fig. 1. The recall scores were entered into a 2 (groups) by 10 (serial positions) repeated measures ANOVA. The overall difference between IQ groups was in the expected direction but of marginal reliability, $F(1,54) = 3.63$, $p < .10 > .05$. The effects of serial position were statistically significant, $F(9,486) = 17.61$, $p < .01$, as was the Groups by Serial Position interaction, $F(9,486) = 2.53$, $p < .01$. As one can see from Fig. 1, any superiority in recall on the part of Group S is limited to the initial and middle serial positions. To elucidate the Groups by Serial Position interaction, subsidiary analyses over portions of the serial position curve were performed. The first ANOVA incorporated Groups S and A over initial and middle serial positions, 1-6, and yielded a reliable effect due to IQ, $F(1,54) = 9.50$, $p < .01$, and due to serial position, $F(5,270) = 27.50$, $p < .01$, with no significant variance contributed by the Groups by Serial Position interaction, $F(5,270) < 1$. A second ANOVA for Groups S and A

over terminal serial positions, 7-10, indicated no reliable differences between IQ groups, $F(1,54) < 1$, a significant serial position effect, $F(3,162) = 14.21$, $p < .01$, and no reliable Groups by Serial Position interaction, $F(3,162) = 1.74$. In short, the effects of IQ on recall were most clearly seen in the initial and middle serial positions, confirming expectations based on the Ellis theory and on previous research.

The initial analysis of the rehearsal data focused on the number of rehearsals a particular item received as a function of its serial position in the list. The 5-sec period following each list item constituted a rehearsal set (RS). Each of the six lists had 10 such RSs. For each S, the number of rehearsals that the 1st through 10th list items received was obtained over the 60 RSs. From these measures, the groups' mean number of rehearsals was derived for each input serial position. These mean group scores are illustrated in the right-hand graph in Fig. 1. The greater frequency of rehearsal on the part of Group S, apparent from Fig. 1, proved to be statistically significant, $F(1,54) = 13.48$, $p < .01$, as was the general decrease in rehearsal over serial positions, $F(9,486) = 41.2$, $p < .01$. The reliable Groups by Serial Position interaction, $F(9,486) = 7.67$, $p < .01$, is most readily interpreted as due to a superiority of Group S over Group A over initial and middle, but not terminal, serial positions. It appears, then, that the superior recall on the part of Group S over initial and middle serial positions corresponded to their greater rehearsal of items in those serial positions.

A second analysis of the rehearsal data was devoted to the manner in which Ss responded during rehearsal periods. Inspection of the rehearsal protocols revealed that the 56 Ss could readily be divided into two groups with regard to rehearsal strategies. One group of 28 Ss showed a very active pattern of rehearsal, typically naming the last item heard and then serially recalling previous items. This group of 28 Ss included 21 Ss from Group S and 7 Ss from Group A. We will devote more attention to the performance of the active rehearsers in a moment. The remaining 28 Ss employed a very passive rehearsal strategy which consisted simply of labeling each item as it appeared with no attempt to repeat previous items. This group included 7 Ss from Group S and 21 Ss from Group A. This differential frequency of Ss from Groups S and A, employing either active or passive rehearsal strategies, was highly reliable, $\chi^2(1) = 12.07$, $p < .005$, and meant that children of

Table 1
Mean Number of Rehearsals Per List Accorded a List Item as a Function of Input Serial Position (SP) and Rehearsal Set (RS) for 28 Children Showing Active Rehearsal

RS	SP										Total
	1	2	3	4	5	6	7	8	9	10	
1	1.15										1.15
2	.95	1.24									2.19
3	.98	.98	1.18								3.14
4	.93	.88	.85	1.09							3.75
5	.82	.75	.72	.67	1.01						3.97
6	.67	.60	.63	.60	.53	.91					3.94
7	.61	.46	.45	.37	.43	.32	.88				3.52
8	.56	.40	.33	.30	.34	.28	.35	.88			3.44
9	.48	.39	.35	.26	.25	.22	.24	.24	.88		3.31
10	.46	.38	.30	.25	.21	.20	.18	.20	.19	.89	3.26
Total	7.61	6.08	4.81	3.54	2.77	1.93	1.65	1.32	1.07	.89	

superior intelligence were more apt to be active rehearsers. It should also be pointed out that Ss were quite consistent in their rehearsal strategies, i.e., if S showed active rehearsal on one list, he did so for all six lists. Similarly, those who simply labeled during the time provided for rehearsal did so on all six lists. The mean number of rehearsals on a typical 10-item list, which the items in each input serial position received on each of the 10 rehearsal sets for the 28 Ss showing active rehearsal, are listed in Table 1. The entry .60 at SP_2 , RS_6 , for example, means that the second list item received, on the average, 6/10 of a rehearsal in the 5-sec period following the presentation of the sixth item in the list. The row totals in Table 1 indicate the number of rehearsals occurring during each RS. The number of rehearsals varies as a function of RS, $F(9,243) = 37.10$, $p < .01$, with a rise from 1.15 rehearsals at RS_1 to a high of 3.97 at RS_5 , and a subsequent decline to 3.26 at RS_{10} . This rise and fall over rehearsal sets is reflected in reliable linear and quadratic trends, with the linear accounting for 32% and the quadratic for 59% of the variance. The column totals in Table 1 index the number of rehearsals given each item over rehearsal sets as a function of its serial position. The effects of serial position are highly reliable, $F(9,243) = 109.10$, $p < .01$, and the reliable linear trend accounts for 90% of the variance. The earlier the item in the list, the more rehearsal it received. This disproportionate share of rehearsals paid to the early items was not due simply to the fact that early items had more opportunity to be rehearsed. If one scans the data in Table 1 row by row, starting with RS_1 , it is apparent that primacy effects occurred during each RS. The Ss, in effect, were taking pains to insure that early items were constantly being recirculated.

In summary, children of superior intelligence exhibited greater free

recall than children of average intelligence, but this advantage in recall was limited to the initial and middle portions of the serial position curve. Children of superior intelligence also tended to employ more active rehearsal strategies, resulting in a greater number of rehearsals for items occurring in initial and middle serial positions. The present results, in accord with those of Fagan and Binzley, indicate that the two-process view of immediate recall, with its emphasis on rehearsal as a transfer mechanism, used by Ellis to identify sources of memory disparities between normal and retarded adolescents, may be generalized to include comparisons of children of superior intelligence with children of average intelligence.

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