A rehearsal deficit in retardates' continuous short-term memory: Keeping track of variables that have few or many states*

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Mildly retarded children (CA = 16, MA = 9) were tested on a continuous short-term memory task that required them to keep the current state of a number of variables updated. Performance was dependent on the number of states of the probed variables, and there was a marked recency but no primacy effect in the serial position curves. These data are similar to those obtained with preschool children but quite different from those typically found with adults. It is suggested that the developmentally young perform poorly on such tasks because they fail to rehearse the current state of the to-be-remembered variables.

A keeping-track task of the type introduced independently by Yntema & Mueser (1960) and Lloyd, Reid, & Feallock (1960) requires that the S keep track of the present state of a number of variables or categories. Questions or cues that signal the S to recall the most recent state of a particular variable are interpolated within a sequence of messages about the states of the variables. Not only would the ability to keep track of a number of things at once appear to be an important form of memory for everyday life, but the task provides an excellent vehicle for studying memory strategies such as rehearsal and controlled forgetting. The ability to keep constantly changing material updated would seem to require both rehearsal of the present state of a variable and erasure of previous states. Recent evidence suggests that retarded children are unlikely to use verbal rehearsal spontaneously as a deliberate mnemonic technique (Belmont & Butterfield, 1969, 1971; Ellis, 1970) and as such should experience difficulty with the keeping-track task.

Morin, Hoving, & Konick (1970) adapted the keeping-track task for use with children. The task included a number of variables: food, animals, toys, and vehicles. Each of the variables in turn had a set number of states. Thus, the six states of the food variable were: bread, milk, apple, cake, pie, and hot dog. On each trial, the S was presented with four items

sequentially in an inspection set. One item came from each of the four variables, e.g., bread, dog, glove, and boat. The S's task was to remember the most recent state of each variable, e.g., that bread was the last food seen.

How does the S decide which food he saw? Logically, he can answer the question by searching his memory of the states in the inspection set and determining which one is a food, or he can search through the possible foods and determine which one was seen ("tagged") most recently. Since there are relatively few items in each variable, these items recur frequently, and the recency judgments required by the second strategy would be difficult to make (Brown, 1973; Morin, Donaley, & Forrin, 1970). Given this level of difficulty, it would appear that the most efficient strategy would be to remember (through rehearsal) the last inspection set of four items, as this set always contains the updated information needed to answer the probe.

Investigations of this type of task with adults have shown that performance is not affected by the number of states of each variable (Yntema & Mueser, 1962). Thus, the functional search set for adults appears to be the inspection set and not the states of the variable in question. Searching only this set provides all the updated information and alleviates the necessity of "time-tagging" (Yntema & Trask, 1963) the items of the probed variable so that recency judgments can be made. However, this optimal strategy demands that the items in the preceding inspection set be maintained in memory until the probe occurs. The most efficient method of preserving the rapidly presented and constantly changing items in memory is to actively rehearse the most recent inspection set until the probe occurs.

Unlike adults, the performance of preschool children was affected by the number of states of a variable (Morin, Hoving, & Konick, 1970). The number of errors increased significantly as the number of states of a variable increased. In answering the probe, the children must consider the states of the probed variable rather than concentrating exclusively on the items in the inspection set. The explanation of the data favored by the authors was to posit a rehearsal deficit, the Ss were forced to search the probed variable because they failed to keep the information concerning the inspection set "alive" until the probe occurred, due to inadequate rehearsal.

The only study of keeping-track performance that specifically required the Ss to rehearse was conducted with adults (Alden, Wedell, & Kanarick, 1971). Using an inspection set of eight items, a marked primacy and recency effect was found in the serial position curves, with retrieval of the first two and last serial positions being most efficient. The presence of a primacy portion of a serial position curve has recently been attributed to the effect of rehearsal mechanisms (Atkinson & Shiffrin, 1968; Ellis, 1970; Waugh & Norman, 1965). However, when the serial position curves obtained with preschool children were examined, there was no evidence of a primacy effect as there had been with rehearsing adults (Morin, Hoving, & Konick, 1970). In the present study, the keeping-track performance of retarded children was examined, as these Ss have also been described as deficient in the use of rehearsal strategies (Ellis, 1970). The keeping-track task also has a number of advantages when compared to other procedures used to assess retardates' short-term memory. The typical procedure has been the one used by Ellis (1970). Here the Ss are shown a series of digits followed by a probe requiring the Ss to give the position of the presented digit. Hence, memory for serial position is required and the data are subject to a position response bias (Calfee, 1970). Inferences about the extent of rehearsal are derived from the shape of the serial position curves. In the keeping-track task, the S is not required to identify the serial position of an item but is required to answer the probe with only item information that is not subject to a position response bias. Further, there are two sources of evidence concerning a rehearsal deficit. In addition to the serial position effect, there is also relevant evidence drawn from a consideration of the effects of number of states. That is, while the Ellis procedure relies on the serial position curve to make inferences concerning

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rehearsal, the keeping-track task provides both this information and information about the effect of number of states. Ss deficient in rehearsal should show no primacy effect and should show an effect due to number of states. Finally, if the rehearsal deficit characteristic of young children and retardates in serial recall tasks (Belmont & Butterfield, 1969, 1971; Flavell, Beach, & Chinsky, 1966; Flavell, Friedrichs, & Hoyt, 1970; Kingsley & Hagen, 1969) is also found to be operating in the keeping-track task which does not require serial information, this would suggest that a rehearsal deficit may be a stable characteristic of the Ss over a variety of tasks and situations.

SUBJECTS

The Ss were 12 institutionalized retardates selected from the Mansfield State Training School without regard to sex or diagnostic category. They ranged in age from 12 years 2 months to 18 years 10 months, with a mean CA of 16 years. Their MA range was 7 years 4 months to 12 years 7 months, with a mean MA of 9 years. Their IQ range was 62-85, with a mean IQ of 70.

APPARATUS

The stimuli were presented by means of a Wisconsin General Testing Apparatus (WGTA). The S and E sat facing each other with a one-way vision screen interposed. The main feature of the apparatus was a 30 x 12 in. sliding tray. This tray was pulled out of sight behind the one-way vision screen for E to select and position the stimuli and pushed out directly in front of the S for each trial. On the E's side of the apparatus, storage compartments were placed so that each specific picture could be replaced in the same location after use and would be readily available to the E as required.

STIMULUS MATERIALS

The stimulus pool consisted of 24 colored pictures cut from children's books and pasted onto 3½ x 3½ in. black posterboard cards. The pool of 24 pictures consisted of four variables, each comprised of six possible states: *people*—man, woman, baby, boy, girl, and granny; *animals*—dog, cat, mouse, cow, rabbit, and lion; *foods*—apple, cookie, egg, cake, bread, and milk; *clothing*—coat, shoe, glove, pants, dress, and sweater. A set of 4 (28 x 28 in.) probe cards were used. Each probe card contained a large yellow question mark in the center and a small line drawing (approximately 2 x 2 in.) representing one of the variables in the extreme left-hand side of the card. This identified the variable being probed. The line drawings represented a state of the variable not included in the stimulus pool (a deer, a hat, a stick

figure of a man, and an ice cream cone).

PROCEDURE

Each S was tested for a total of 8 days: 2 days of stimulus familiarization, 2 days of pretraining, and 4 days of experimental sessions.

Stimulus Familiarization

All Ss received the same stimulus familiarization. Testing was conducted individually with the S and E seated together at a small table. From the available 24 pictures, four different sets of 16 pictures were selected and three Ss were assigned randomly to one of these four sets. A set of 16 pictures always consisted of two states of one variable, four states of two variables, and six states of the remaining variable. The specific set of 16 pictures assigned to an S constituted his stimulus pool and remained the same throughout the experiment.

The E presented the 16 pictures to the S one variable at a time and said, "These are pictures of different [animals, etc.]," and the S was required to name all the states of that variable before proceeding to the next variable. The E presented each variable in turn. If an S was unable to name a state, he was told the name and asked to repeat it. The states of the variables were presented one at a time until the S could name them all without error on three successive presentations.

On the second day of stimulus familiarization, the 16 cards were presented in an unsystematic order in a circle in front of the S, who was required to select all the states of a given variable—i.e., the E said, "Give me all the foods," "Give me all the animals," etc. The S was further required to name the states as he handed them to the E. This process was continued until the S could select all states of all variables without error of selection or naming for six consecutive trials. At the beginning of each of the 6 subsequent days of testing, the S's set of 16 cards was shown to him and he was required to name them and place them in category correctly before each day's testing.

Pretraining

On each of the 2 days of pretraining, the Ss received 24 trials. On Day 1, the first 12 trials presented an inspection set consisting of only one item (e.g., a dog) and the probe asked the S which (e.g., animal) he saw last. On the remaining 12 trials, the inspection set consisted of two items. On the second day, the first 12 trials presented an inspection series of three items and the remaining trials used inspection series of four items. With the exception of the graduated sequence of items in the inspection set, the procedure in the pretraining

sessions was identical to that described for the experimental sessions. In the initial pretraining sessions, the Ss were also familiarized with the line drawings on the probe cards identifying the probed variable.

Experimental Sessions

The Ss were individually tested, seated in front of the WGTA. Each trial consisted of the sequential presentation of four stimuli followed by a probe. The four items in the inspection series always included one state from each variable, e.g., an animal, a person, a food, and an article of clothing. The order of presentation was counterbalanced so that each state occurred approximately the same number of times and in each serial position. The probe was a question that asked for the most recent state of a variable, e.g., "What animal did you see last?" The Ss replied with the name of an animal. The probe question was accompanied by the presentation of a card containing the appropriate line drawing in the left-hand side of the card and one large yellow question mark in the center. No S was continued in the experiment if he gave anything other than the name of one state of the probed variable (e.g., a nonanimal).

On each trial, the E placed the four stimuli in the inspection series face down in a row on the WGTA tray and presented the tray to the S. The Ss were instructed to turn each card face up, one at a time, in serial order, beginning at the S's left. Only one card was in view at any one time as the Ss were instructed to return the card to its face-down position after viewing. The viewing session was self-paced, but approximately 2 sec were required to view each picture. After the last picture had been viewed, the E immediately withdrew the tray and asked the probe question. Approximately 2 sec intervened between the exposure of the last item in the inspection set and the probe question. The intertrial interval was approximately 10 sec.

There were 12 problem types consisting of all possible combinations of probing each of four serial positions (in the inspection set) of the variables containing two, four, or six states. Two repetitions per day of each problem type were given. With 4 days of testing and 12 Ss, the design yielded 96 observations of each of the 12 problem types.

An additional feature of the counterbalancing procedure was that an attempt was made to control the stimulus recurrence distributions across variables having an unequal number of states. This factor has been found to be an important variable in keeping-track tasks (Morin, Hoving, &

Konick, 1970; Morin, Donaley, & Forrin, 1970). In order to control for unequal stimulus recurrence distributions, the order of presentation was designed so that a repeat of a particular state occurred on approximately every fourth trial (e.g., for a variable having two states, a pattern such as dog, cat, dog, dog, cat, dog, cat, cat would be followed, and for a variable having six states, the pattern might be dog, cat, lion, lion, mouse, cow, rabbit, rabbit).

At the end of each testing session, the Ss were permitted to choose a selection of candy as a reward.

RESULTS

All analyses were conducted on the adjusted error scores, as guessing probabilities differ for variables with unequal numbers of states. Therefore, following the procedure of Morin, Hoving, & Konick (1970), individual error scores were adjusted by the formula $E \text{ adjusted} = E + (E/N - 1)$, where E is the observed number of errors and N is the number of states of the probed variable. The adjustment was applied to the data of individual Ss at each serial position for each number of states.

In Fig. 1, the mean adjusted proportions correct as a function of number of states and serial position are presented. It can be seen that performance improves as the number of states decreases, and there appears to be a marked recency but no primacy effect in the serial position curves.

A 3 (states) by 4 (serial position) by 12 (Ss) factorial analysis of variance was conducted on the adjusted error scores. Confirming the visual impression from Fig. 1, the main effect of states was reliable [$F(2,22) = 30.60, p < .001$]. The main effect of serial position was also reliable [$F(3,33) = 32.46, p < .001$]. Post hoc t tests revealed that performance was significantly better in Serial Position 4 than in the other three conditions, which did not differ significantly from each other. The interaction of States by Serial Position fell just short of an acceptable level of significance ($p \approx .10$).

DISCUSSION

The data provide a replication and extension of the results obtained by Morin, Hoving, & Konick (1970) and indicate that retarded children perform in a keeping-track task in a manner more similar to preschool children than to rehearsing adults. Performance decreased as the number of states of the variable increased, suggesting that the states of the variable are considered when the answer to the probe is required. Furthermore, inspection of the serial position curves shows a marked

Fig. 1. Mean adjusted proportion correct as a function of serial position and number of states.

recency effect but no primacy effect, again a pattern of results similar to that found with young children (Morin, Hoving, & Konick, 1970) but not rehearsing adults (Alden et al., 1971). Thus, evidence for a rehearsal deficit in retarded children was found in a short-term memory task that does not require serial information. This finding extends the generality of the rehearsal deficit found in serial recall tasks (Belmont & Butterfield, 1969; Ellis, 1970) and suggests that such a deficit may be a reasonably stable characteristic of this S population.

These data do not, of course, suggest that retarded children's performance could not be improved by training, and indeed Belmont & Butterfield (1971) have previously reported successful rehearsal training on a serial recall task. It should also be remembered that in the adult study where a primacy effect was obtained (Alden et al., 1971), the Ss were required to rehearse the material. Specifically training retarded children to rehearse the inspection set before each probe may result in a serial position curve more like that of adults than of preschool children. However, the absence of an effect due to states, also seen as evidence of rehearsal, was obtained with adults who were not specifically requested to rehearse (Yntema & Mueser, 1962). Thus, the present data indicate that retardates, unlike adults, do not spontaneously adopt the appropriate strategy of active rehearsal in a keeping-track task.

As a final note of interest, it should be mentioned that the same children served as Ss in both the keeping-track task reported here and in a continuous

recognition memory task reported earlier (Brown, 1972). When recognition of long sequences of pictures was examined, the excellent performance of these same Ss paralleled that of adults. Apparently, the main difference is that the keeping-track task requires the use of a deliberate mnemonic strategy (rehearsal), while the recognition task does not. These data support the growing body of evidence that suggests that the developmental young perform poorly on memory tasks that demand mediation via deliberate mnemonics (Flavell, Friedrichs, & Hoyt, 1970) but not on those tasks that do not require such mediation (Brown, 1973; Brown & Scott, 1971).

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