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Four types of sentences differing in grammaticalness and amount of association between component words were presented to 80 educable mentally retarded children for recall after varying delay intervals. The children (all male and between the ages of nine and 14) sat quietly during the delay intervals of named numbers from a memory drum. The results showed a significant effect of type of sentence, nature of delay activity (silence versus number naming), and length of delay activity. A significant interaction of length of delay interval by nature of delay activity was also found. The results were interpreted as reflecting inefficient organizational strategies in processing linguistic strings. (Author/DO)

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EFFECTS OF GRAMMATICAL AND ASSOCIATIVE STRUCTURE, DELAY INTERVAL, AND ACTIVITY DURING DELAY ON MEMORY SPAN OF EDUCABLE RETARDED CHILDREN[1]

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4 types of sentences were constructed differing in grammaticalness and amount of association between component words. These sentences were presented to educable mentally retarded subjects (EMRs) for recall after varying delay intervals. Subjects sat quietly during the delay intervals or named numbers from a memory drum. The results showed a significant effect of type of sentence, nature of delay activity (silence vs. number naming), and length of delay activity. A significant interaction of length of delay interval by nature of delay activity was also found. The results are interpreted as reflecting inefficient organizational strategies in processing linguistic strings.

Several attempts have been made to explain the behavioral inadequacies of mentally retarded (MR) children. One promising position was posited by Ellis (1963) who contends that MR children suffer from a "diminished stimulus trace" which is evidenced through a characteristic short-term memory deficit. Ellis' theory derives support from a variety of empirical studies (see Ellis, 1963, Ch. 4). However, the short-term memory deficits of EMRs may be due to faulty stimulus organization. Spitz has offered considerable evidence which indicates that MRs show a particular deficit in recoding stimulus input.

Bateman and Wetherell (1965) noted the effects of memory deficits of MR children on specific scales of the Illinois Test of Psycholinguistic Abilities (ITPA). MR children reveal a typical profile of psycholinguistic deficiency in the "entire automatic-sequential level" as compared to the "representational level" of the ITPA. The automatic-sequential scales of the ITPA comprise a test of simple morphologic usage (Auditory-Vocal Automatic scale), a digit span repetition test (Auditory-Vocal Sequential scale), and a test of visual memory for a sequence of geometric figures (Visual-Motor Sequential scale). Bateman and Wetherell conclude that the immediate memory problems of retarded children are particularly distressing because these disabilities are extremely difficult to remediate. According to these authors, memory skills may be more closely related to genetic factors than are other psycholinguistic abilities.

While deficiencies in short-term memory appear to be a ubiquitous phenomenon among retarded children, several questions regarding the nature of this deficiency remain unanswered when applied to language behavior. Stimuli such as a sequence of digits or geometric figures have no apparent grammatical or associative structure typically present in syntactically ordered linguistic stimuli. Relatively little is known about how the structure of linguistic strings (i.e., the degree of syntactical and/or associative structure) affects the short-term memory span of MR children.

The present investigation used sequences of two through eight-word strings constructed to differ in the degree of grammaticalness and associative strength. These stimuli were presented to educable mentally retarded (EMR) children using three presentation-recall delay intervals. Subjects either sat quietly during the delay intervals or were required to name numbers appearing on a memory drum prior to recalling the linguistic stimuli presented to them.

Method

Subjects. Eighty educable mentally retarded (EMR) children were randomly selected from the 9- to 14-year-old male population of the Wayne County Training School, Northville, Michigan. Subjects were then randomly assigned to one of two delay activity subgroups (Silence or Number Naming) and one of the four linguistic stimuli subgroups. This procedure resulted in the assignment of ten subjects from each of the delay activity subgroups to each type of linguistic string. Table 1 summarizes the distribution of CA, MA, and IQ for the subjects.

Insert Table 1 about here

Linguistic stimuli. Four different types of linguistic stimuli were constructed such that each could be assumed to differ in the degree of grammaticalness and/or associative structure. The following types of stimuli were used:

1. Context sentences (CS). These strings were composed of a meaningful sequence of words conforming to the syntactic rules of standard English and were assumed to have relatively high associative strength between adjacent words in the string. They are simple meaningful sentences (e.g., Young people enjoy music).

2. Anomalous sentences (AS). These strings are assumed to be composed of a sequence of words which generally conforms to the syntactic rules of standard

English but have relatively low associative dependencies between units in the string. They are essentially meaningless sentences which follow conventional syntactic structure (e.g., Brave trees fly children).

3. Context sentences reversed (CSR). These strings are assumed to contain a relatively high degree of association between adjacent words but are distorted in grammaticalness by reversing the syntax of meaningful CS strings (e.g., Music enjoy people young).

4. Random strings (RS). These stimuli are assumed to contain relatively low associations between words in sequence and to have a relatively low approximation to the rules of English syntax. The RS stimuli are constructed by randomly assigning words from the pool used to construct the CS stimuli to strings of various lengths (e.g., Eggs tree jump happy).

All but three words used in the construction of the stimuli were of either A or AA frequency on the Thorndike-Lorge list. Each type of string varied in length from one to eight words. Three strings of the same length were constructed for each length of sentence--one for each delay interval.

Procedure. Subjects were first administered the number stimuli from the Auditory-Vocal Sequential subtest of the ITPA in order to determine immediate memory span for digits.

The second phase required all subjects to practice naming numbers from one through nine arrange randomly on a standard memory drum.

The next phase involved the presentation of four two-word practice phrases followed by either a period of silence during which the subject was instructed to sit quietly and wait for the signal to recall the sequence or to name the numbers on the memory drum (as previously learned in Phase II) and to recall the word strings when hearing the signal (a short duration tone) to do so. The specific instructions administered to the subjects at each phase of the experiment were as follows:

Phase I: DIGIT REPETITION (ITPA Subtest)

> "Say, 1--2. (Pause) Good. Say, 7--3--2." Etc. (Digits were presented at a rate of one per second.)

Phase II: INTERPOSED ACTIVITY (Number Naming)

> "What is this number (pointing to the first number appearing in the window of the memory drum)? (Pause) Good. What is this one (moving the memory drum tape to the next number in the group)? (Pause) Fine. Now you name each number as it appears in the window until you hear this sound (short tone)." (Each subject subsequently named three successive numbers and then six successive numbers from the memory drum.)

Phase III: WORD-SENTENCE REPETITION

"Here are some words for you to remember: chocolate cake. Now start naming these numbers (pointing to the memory drum). Stop! (Tone simultaneously) What were the words I told you to remember?" (Pause) (Four examples were used for each sentence type.)

Subjects who were randomly assigned to the silence condition during the delay intervals received the same pretraining except that they were told to sit quietly and wait for the tone prior to recalling the sequence.

Phase IV: EXPERIMENTAL TASK

After completing Phase III, the experimenter said, "Now listen carefully and remember to tell me what I said when you hear this sound (tone)." The number naming group was told to "remember to name the numbers, then say what I said when you hear this sound (tone)." The silence group was told to remember to sit quietly while waiting for the tone.

The experimenter presented the one-word stimuli first. There were three one-word stimuli--one at each of the three delay intervals (1, 6, or 20 sec.); the tone followed each delay interval. The experimenter then moved to the two-word strings, and then to the three-word strings, etc. Delay intervals were randomly assigned to each of the three strings within each sequence length (one-word through eight-word sequences). Hence, all subjects received all delay intervals within each set of word string lengths. The length of the longest string correctly repeated was the raw score received by the subject. The subject could receive a maximum score of eight--the longest string of units. The task was terminated when the subject incorrectly repeated three sequences of the same number of words.

Results

The data were analyzed through a 4 x 3 x 2 mixed ANOVA design. The effects of Type of Linguistic String, duration of Presentation-Recall Delay Interval and the nature of Interposed Activity During Delay were assessed. Table 2 presents the summary of this analysis.

Insert Table 2 about here

Table 3 presents the means and standard deviations for length of memory span for subgroups that received the four types of linguistic strings under the three delay durations. The digit span data obtained from the ITPA Auditory-Vocal Sequential scale is presented in Table 3 for convenient comparison with the other memory span data.

Insert Table 3 about here

Figure 1 graphically indicates the nature of the significant AC interaction (see Table 2). While performance was unaffected as a function of increased delay under the silence condition, a progressive decrement in memory span was evidenced among subjects who engaged in the intervening number naming activity. The Tukey procedure (Winer, 1962) revealed no significant differences between delay intervals among subjects in the silence condition. A significant difference ($p < .01$) did appear between all delay intervals under the intervening number naming condition. Significant differences ($p < .01$) were revealed between the silence and number naming conditions for the 6 sec. and 20 sec. delay, but as expected, not for the 1 sec. comparison.

Insert Figure 1 about here

Table 2 also reveals a significant main effect of interposed activity during delay (A). While this generalization is limited by the observed AC interaction, it is noted that the silence subgroup obtained a mean of 3.98 (SD = 1.49) while the number naming subjects revealed a mean of 2.61 (SD = 1.51) words.

Analysis of the significant effect of presentation-recall delay interval (C) revealed a mean of 3.66 (SD = 1.52) at 1 sec., 3.29 (SD = 1.56) at 6 sec., and 2.94 (SD = 1.77) at 20 sec. when pooling the data across all subgroups. The difference between the means was significant for 1 and 6 sec. ($p < .05$), 1 and 20 sec. ($p < .01$) and 6 and 20 sec. ($p < .05$) comparisons.

The structure of the linguistic stimuli (B) did not interact with either of the two delay variables studied. However, from Table 2 it can be seen that the type of linguistic string was a significant factor influencing the mean length of the subjects' memory span. Figure 2 illustrates the nature of this effect. Subjects who were asked to recall the meaningful sentences (CS strings) performed better ($\bar{X} = 4.48$, SD = 1.94) than those who received the reversed sentence (CSR) strings ($\bar{X} = 3.35$, SD = 1.27), anomalous (AS) strings ($\bar{X} = 2.69$, SD = 1.38), or random (RS) strings ($\bar{X} = 2.67$, SD = 1.19). Tukey analysis revealed that the mean memory span scores for the CS subgroups were significantly higher ($p <$ 01) than the mean scores received by the subjects in each of the remaining three subgroups. There were no significant differences between the CSR, AS, or RS means.

Insert Figure 2 about here

Digit span scores for each subgroup are plotted in Figure 2. It is noted that, as expected from random assignment of subjects, all subgroups performed similarly on the sequential recall of digits. Further inspection of Figure 2 reveals that all subjects recalled longer strings of digits than sequences of words. It is noted that the curve for linguistic stimuli represents the pooled data across both delay intervals and interposed activity during the delay periods, whereas the digit span data represent the results of immediate recall. Therefore, no attempt was made to evaluate the statistical significance of the differences between memory span for digits and the means for the different types of linguistic strings. For heuristic purposes it appeared useful to compare the performance of subjects under the 1 sec. delay condition with the digit span data. The 1 sec. delay condition most closely approximated the conditions under which the digit span data were collected. Hence, the means for subjects in the four different linguistic string subgroups, under the 1 sec. delay condition, are also presented in Figure 2.

Discussion

Miller (1956) contends that new material is processed through the recoding of units into chunks of information. When the units of a sequence of stimuli are recoded into a smaller number of chunks corresponding to the size of the child's memory span, recall is facilitated. If such a process is characteristic of EMR children's functioning then it appears reasonable to expect subjects to recall longer strings of syntactically or associatively structured units when compared to strings of randomly organized words or digits. Structured verbal material contains recoding cues, whereas unstructured stimuli require subjects to impose their own structure by invoking a recoding strategy. In the present study memory span for semantically anomalous sentences and strings having high inter-word associations but distorted syntax did not significantly differ from memory span for random strings. However, subjects did recall longer strings of meaningful sentences when compared to the other types of verbal stimuli studied.

The findings suggest that neither associative nor syntactical structure acted independently to cue recoding strategies of the EMR children. Only when interacting in a meaningful semantic context did these structural variables facilitate the recall of subjects. It is, however, relevant that while subjects were more successful in recalling the meaningful sentences than other types of stimuli, mean performance under the 1 sec. delay condition was relatively poor when compared by inspection to digit span scores. Normal adult subjects typically have better memory span for meaningful sentences than for digits (Miller, 1963). The relatively better digit span performance observed in the present study when compared to the recall of different types of verbal strings may be due to stochastic phenomena differentiating linguistic from number stimuli. There are obviously fewer numbers than words in the EMR child's repertoire. Hence, the probability of recalling a sequence of digits is greater than for recalling a sequence of words.

Decay in memory span appeared as a function of increased delay interval under the number naming condition but not under the silence condition. The silence condition may have permitted subjects to rehearse and thereby facilitated their performance and prevented a decrement as a function of the duration of the delay period. On the other hand, the number naming condition may have produced an accumulation of interference which depressed overall memory span and effected a decrement in performance as a function of delay interval.

In view of the present data, the investigators are led to the speculation that when applied to language behavior, the short-term memory deficit of retarded children is probably due to faulty or inefficient organization of input (Spitz, 1966). EMRs may have relatively weak recoding abilities and take little advantage of the associative and syntactical structure inherent in the verbal material to be processed. While meaningfulness of materials appears to have a facilitating effect on memory span of EMRs, it does not appear to facilitate the rate of a diminishing stimulus trace. The EMRs' ability to delay a response appears to be a function of the activity during the delay period. With no intervening activity during delay intervals up to 20 sec., EMRs appear to invoke rehearsal strategies resulting in no adverse effects on memory span. Detrimental effects on recall result as a function of requiring subjects to participate in an intervening verbal task during the delay interval--under this latter condition, a decrement in performance as a function of the duration of the delay interval is probably due to the cumulative effect of interference on an inefficiently organized input.

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Footnote

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Figure Captions

Fig. 1. The effect of delay interval and delay condition upon short-term memory.

Fig. 2. Linguistic structure subgroup means pooled across delay periods and activity during delay, subgroup means for 1 sec. delay condition, and mean Auditory-Vocal Sequential (ITPA digit span) scores.

Table 1

Subgroup Means and Standard Deviations

for CA, MA, and IQ

Delay Activity	Type of Linguistic String		CA	MA	IQ
Silence (N=40)	Context (CS)	Mean	140.00	8.19	70.40
		SD	13.23	0.91	6.25
	Anomalous (AS)	Mean	139.50	8.18	70.40
		SD	14.12	1.01	5.04
	Reversed (CSR)	Mean	141.00	8.30	70.70
		SD	14.19	1.12	6.25
	Random (RS)	Mean	141.70	8.43	70.50
		SD	15.40	1.00	6.33
Number Naming (N=40)	Context (CS)	Mean	139.60	8.16	70.10
		SD	14.73	1.05	5.32
	Anomalous (AS)	Mean	138.30	8.25	71.70
		SD	14.31	1.24	5.39
	Reversed (CSR)	Mean	140.80	8.21	70.10
		SD	13.43	0.97	5.70
	Random (RS)	Mean	139.90	8.13	69.80
		SD	17.50	1.07	5.02

NOTE -- All subjects were males

CS = Context Strings
AS = Anomalous Strings
CSR = Context Strings Reversed
RS = Random Strings

Table 2

Summary of Analysis of Variance
for the Three Factors Studied

Source		SS	df	MS	F
Between Ss					
A	(Intervening Delay Activity)	110 71	1	110.71	36.78**
B	(Type of Linguistic String)	131.05	3	43.68	14.51**
AB		8.14	3	2.71	0.90
Error (between)		216.77	72	3.01	
Within Ss					
C	(Delay Interval)	21.04	2	10.52	13.49**
AC		27.63	2	13.82	17.71**
BC		7.56	6	1.26	1.62
ABC		8.77	6	1.46	1.87
Error (within)		112.33	144	0.78	

** Sig. < .01 level

Table 3

Mean Scores for Type of Linguistic Strings Under Different Presentation-Recall Delay Conditions

(N=80)

		Type of Linguistic String*							
		CS		CSR		AS		RS	
Intervening Activity:		Sil.	N.N.	S.T.	N.N.	Sil.	N.N.	Sil.	N.N.
Delay Interval:									
1 sec.	$\bar{X}$	4.70	4.80	4.20	3.30	3.56	2.40	3.20	3.20
	SD	2.11	1.81	1.40	1.06	1.13	1.17	0.79	0.92
6 sec.	$\bar{X}$	5.00	3.70	4.00	2.60	3.80	1.40	3.30	2.50
	SD	1.63	1.49	1.05	0.84	1.03	1.07	1.06	1.35
20 sec.	$\bar{X}$	5.80	2.90	4.00	2.00	3.50	1.50	2.70	1.10
	SD	2.04	1.45	0.94	0.67	0.71	0.85	0.67	0.74
ITPA Digit Span:	$\bar{X}$	5.10	4.80	4.90	4.70	5.22	4.40	4.70	5.00
	SD	0.99	1.03	1.20	1.16	1.31	0.52	0.82	0.94

*Key to abbreviations: Context Sentences (CS); Context Sentences Reversed (CSR); Anomalous Strings (AS); Random Strings (RS); Silence during delay interval (Sil.); Number Naming during delay interval (N.N.).

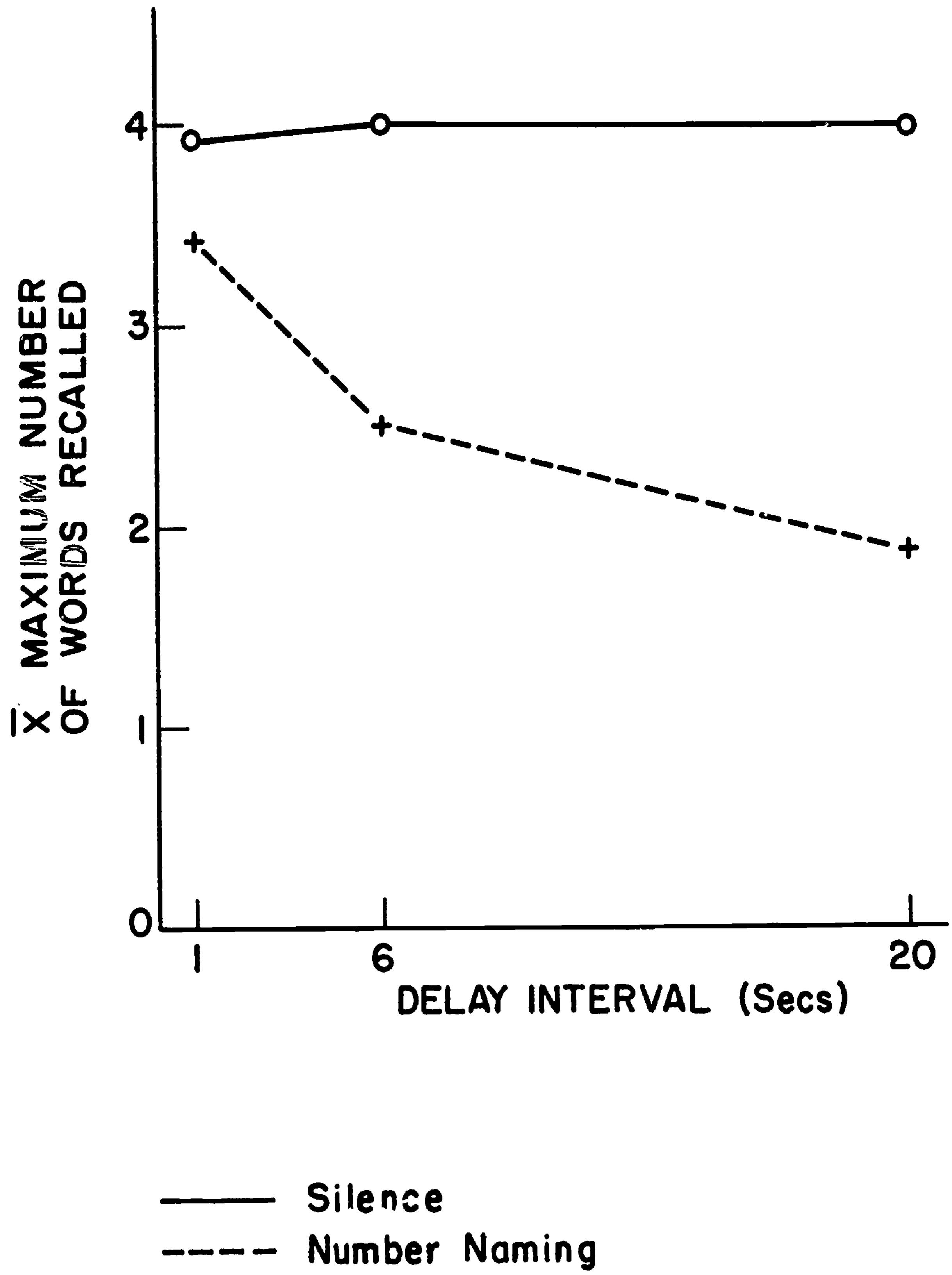
4
3
2
1
0
$\bar{X}$ MAXIMUM NUMBER OF WORDS RECALLED
1
6
20
DELAY INTERVAL (Secs)
Silence
Number Naming

Figure 1

CS = Context Sentences

AS = Anomalous Sentences

CSR = Context Sentences Reversed

RS = Random Strings