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STIMULUS PRESENTATION RATE AND RETARDATE DIGIT SPANS

By

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Abstract

In an effort to provide evidence for the effects of stimulus presentation rate upon the digit span performances of mental retardates, four retarded *S*s (IQ = 48.5; CA = 16.8) were run in a successive auditory digit span experiment. Each *S* served in each of four rate conditions: 1/2, 1, 2, and 4 digits per second. Digit spans were found to be directly related to presentation rate ($p < .0001$). The results are consistent with other short-term memory data if MA is assumed to be a critical variable determining the effect of presentation rate upon digit span performance. The data indicate that at MAs greater than approximately 9.6 years, presentation rate and digit span are inversely related. Below approximately 9.6 years, however, presentation rate and digit span are directly related.

Stimulus Presentation Rate and Retardate Digit Spans[1][2]

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According to reviews by Kinsch (1970) and Aaronson (1967), the effects of stimulus presentation rate on performance variables in short-term memory (STM) paradigms are not well understood. The chief finding in probe-type paradigms is that normal Ss perform best at slow presentation rates (about 1 per second) compared with higher presentation rates (about 4 to 10 per second) (see, for example, Norman, 1966). Ellis (1970), in a similar probe-type paradigm using 1/2 per second and 2 per second rates, obtained similar results for a normal group but found no effect of presentation rate for a retardate group (IQ = 61; CA = 20).

Bachelder (1970) obtained similar results using a memory span paradigm with institutionalized [institutional] adults of borderline intelligence (IQ = 83) and mild and moderate retardation (IQ = 60). In the memory span paradigm *E* measures the largest string size that *S* can produce accurately. The brighter group performed better under slow rates; but the retardate group showed no significant effect of rate (one-half, one, two, and four digits per second). The rate effect within the retardate group, while not significant, was just opposite the effect in the normal, high IQ group; that is, the retardates performed best at four digits per second.

The present study was designed to provide additional evidence for the positive rate effect in retardates. Rather than the group design used by Bachelder (1970), the relatively more precise within-*S*s design was used in the present study. Each *S* served in all four rate conditions: one-half, one, two, and four digits per second. The dependent variable was a threshold-like measure of the largest digit string that each *S* could produce accurately.

Method

Subjects

The *S*s were two boys and two girls, all residents of Western Carolina Center, a residential facility for the mentally retarded located in Morganton, North Carolina. Table 1 presents relevant descriptive information for the *S*s.

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[1] This study was supported by the Department of Psychology and Education, Western Carolina Center (now J. Iverson Riddle Developmental Center), Morganton, North Carolina, 28655. The author thanks Miss Susan Pressley, who conducted the study under his direction.

[2] This electronic file was prepared in October, 2008 from a mimeographed original. The original was edited in minor ways.

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Table 1

Subject Characteristics

	IQ	Age (years)	Digit Span[a]	Years in the institution
Mean	48.5	16.8	3.92	5.88
Range	40-59	12.6-24.3	3.3-4.3	.25-12.4
SD	7.83	4.71	.41	5.11

[a]These scores were taken from the present experimental data collected at one digit per second, the most common rate used in psychodiagnosis.

Materials

The materials were digit strings ranging in size from one digit to seven digits. The strings were generated randomly with the restriction that no digit was repeated in a string.

Apparatus

Square blue poker chips (tokens) were dispensed from a Davis Scientific Instruments universal dispenser (DSI Model 310). The *S*s had had little or no previous experience with these chips, but had had some contact with a new token program which used a different type of token.

Procedure

E measured the successive-auditory digit span under four rate conditions: one-half, one, two, and four digits per second. Stimulus strings were read from a list and timing was maintained by watching a stopwatch before presentation of each string. The *S*s responded verbally and no attempt was made to control the delay between the end of the stimulus string and the beginning of the *S*s' responses.

The "staircase" method (Bachelder, 1970; Cornsweet, 1962; Underwood, 1966) of measuring psychophysical thresholds was the model used for span measurement. In the staircase method the *S*'s accuracy on each trial influences the selection of the stimuli for the next trial. When *S* recalls a string perfectly, *E* presents a string one digit larger. When *S* errs, *E* presents a string one digit smaller. *E* continues in this manner for a predetermined number of trials after which each *S* is assigned a score which is the average of the string sizes actually presented. Note that *S*'s accuracy determines the string sizes presented, but that no attention is given to accuracy when calculating *S*'s score. In the present study each *S* attempted two ascending series of stimulus strings (one-digit through seven-digit strings) until he erred twice consecutively on each series. These series served to give the *S*s practice at the task and to determine the string size to be presented on the first staircase trial. The first string was equal to the largest string correctly recalled in the two ascending series, and each *S* attempted 9 strings.

The *S*'s performance on the ninth string determined the string size which would have been given on the tenth trial, so the tenth trial was not given. Each *S*'s score was the mean of these 10 string sizes.

When *S* arrived in the experimental room *E* encouraged brief conversation then read these instructions:

> I have a simple test here which will tell me how you remember numbers. Try to do the best you can but don't worry if you forget some because I put some very hard ones in which everyone will forget. I am going to read some numbers which I want you to repeat after me just the way I read them to you.

E then administered the two ascending series of digit strings. When S had erred twice consecutively on each of the two ascending series, *E* then read these instructions and began the nine staircase trials:

> That's good. Now you have a chance to earn some money. For each correct response you will receive a token. For every two tokens that you receive, you will be given a penny.

Throughout the session *E* said "right" or "wrong" immediately following string production and approximately coincident with the delivery of tokens. Each *S* had one experimental session on each of two consecutive days; within each session he performed under two rate conditions. There was a two-minute break between conditions in each session. On the second condition of each session *E* again presented the two ascending series at the new rate. The order of the four conditions was randomly determined for each individual *S*.

Results

A 4 X 4 (½, 1, 2, and 4 digits per second X 4 *S*s) analysis of variance was performed on the absolute digit spans. The digit spans obtained were found to be a direct function of stimulus presentation rate ($F = 18.0$; $p < .0001$). Figure 1 graphically shows the effects of presentation rate on the digit spans of the four *S*s, and Table 2 summarizes the results of the analysis of variance.

Table 2
Analysis of Variance of Digit Span Scores

Source	*df*	MS	*F*	*p*
Rate	3	1.08	18.00	<.0001
Subjects	3	1.10	18.33	<.0001
Rate x Subjects	9	.06		
Total	15			

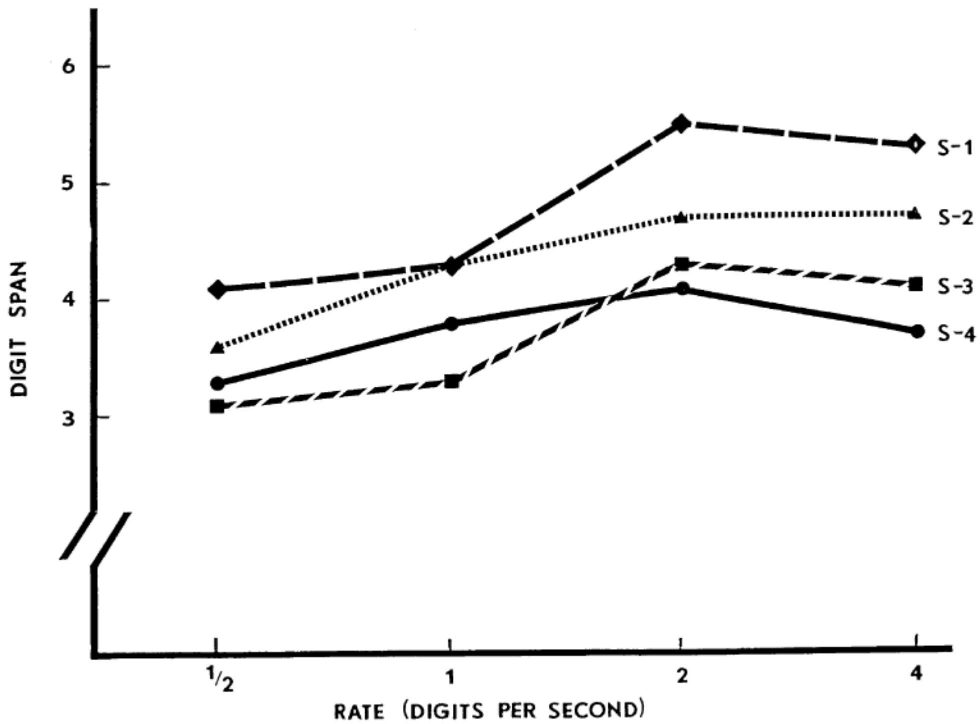

Figure 1: Digit span as a function of rate of presentation. Each curve presents the data for one Subject.

Discussion

Some discussion of the small N (4) in the present study is in order. First, the probability levels ($p < .0001$) are extremely small. More importantly, the individual curves are virtually identical to the group curve [no group curve in the subsitute figure]. Finally, the present curves are very similar to those found by Bachelder (1970). The latter *Ss* were 12 adults living in a different institution in a different state.

The present results, taken with Bachelder's (1970) results, indicate that under certain conditions the digit spans of retarded *S*s vary directly with stimulus presentation rate over the range of one-half to four digits per second. These results partially contradict other studies which have found no effect of rate on retardate STM performance. Perhaps it is the precision of the span paradigm and the within-*S* design which has revealed the effect; or perhaps the rate effect is unique to the span paradigm. It should be emphasized, however, that Bachelder's (1970) results using the span paradigm were quite consistent with Ellis' (1970) results using the probe-type paradigm. The contradiction may be resolved if the MA rather than the IQ is taken as the variable which determines the effect of presentation rate.

If MA is estimated by IQ X CA, and if a top CA of 16 is assumed (the ceiling age for most IQ tests is 16) then the MAs for Bachelder's (1970) borderline normal and retarded adults were approximately 12.8 and 9.6 years, respectively. The estimated MA of the present *S*s is 7.0 years (16 was taken as the age of those older than 16). In other words, it appears that for an MA of approximately 9.6 years rate has no effect. At higher MAs rate and span performance are inversely related, and below an MA of about 9.6, rate and span performance are directly related. Ellis' (1970) results are consistent with this hypothesis. His retardates (IQ = 60.8, CA = 20) had an estimated MA of 9.7 (CA taken as 16 years, calculations by the present investigator). According to the MA hypothesis, a group with an MA of 9.7 should show a slight but small facilitation at slow rates. Ellis' retarded *S*s performed slightly, but nonsignificantly, better in total recall at one-half digits per second compared with their performance at two digits per second.

There is also theoretical reason to suggest that MA should determine the rate effect. Bachelder (1970) explained the rate effect in terms of the *S*'s response repertoire of associated digit sequences. He assumed that everyday use of digits (telephone numbers, ages, prices, weights, money, etc.) results in repertoires of familiar digit sequences. The number and lengths of these familiar sequences should be positively related to MA because of the increasing use of numbers at increasing levels of intellectual development (a culturally determined relationship).

The rate effect was explained as follows: Slow rates of stimulus presentation allow time for the production of associated digit sequences as well as the "target" digit in the digit string. The familiar digit sequences facilitate span performance. Facilitation at slow rates can occur only if the *S* has the associated sequences to produce; that is, only if he has had the requisite experience with digits. Retardates should have had relatively less such experience than normal *S*s and thus should show little or no facilitation at slow rates. At some point, however, very slow rates should allow other extraneous stimuli to interfere with the control of *S*'s behavior, resulting in relatively poorer performance at slow compared to fast rates.

In summary, the proposed rationale explains the most common rate effects observed for normal and mentally retarded *S*s. The explanation is couched in terms of behavior, including both stimulus control functions and response repertoires, rather than hypothetical “processes.” Several studies are implied by this rationale. For example, MA and IQ should be manipulated independently of each other to determine which is the more important predictor of rate effects. Since the rate explanation depends on each *S*’s digit repertoire, further studies should compare the effects of rate on digit performance and common word performance for *S*s of both high and low MA. Most importantly, associated response sequences should be developed experimentally in an attempt to manipulate the rate effect in all *S*s.

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