The verbal loop hypothesis as a predictor of individual differences in short-term recall of tachistoscopically presented binary numbers*

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This experiment was a correlational study designed to investigate the ability of the verbal loop hypothesis to predict individual differences in the recall ability of 51 evening college students presented with 20 arrays of eight-digit binary numbers at exposure times of 0.5 sec. The independent variable was the binary array, and the two dependent variables to be correlated were verbalization length, measured in units of words, and stimulus difficulty, measured in units of number of errors. Glanzer & Clark's (1962) finding of a high negative correlation between stimulus accuracy and mean verbalization length was replicated here by obtaining a high positive correlation between stimulus difficulty and mean stimulus verbalization length. However, there was no relationship found between the characteristic verbalization length of an S and his ability on the experimental task as measured by his total number of errors.

Glanzer & Clark (1962), in attempting to account for differences in stimulus difficulty in tasks involving immediate report of briefly presented visual stimulus arrays, proposed the verbal loop hypothesis. This was the idea that the S encoded a brief visual trace into a more permanent verbal record. They found a high negative degree of correlation between stimulus accuracy and mean verbalization length using patterns of geometric figures as stimuli. They later replicated this work using binary numbers as stimuli for the sake of generality (Glanzer & Clark, 1963).

The foregoing hypothesis is in consonance with the observations of Haber (1964), that people are either object or dimension coders, and with the line of research reviewed by Egeth (1967), both of which suggest that Ss do in fact verbally encode visual stimuli in short-term memory tasks.

It is also in agreement with the serial position effect reported by Harcum (1967) in tachistoscopic pattern perception tasks as, actually, the verbal loop hypothesis reduces this type of experiment to an identity with a serial learning task wherein a serial position effect was noted as early as Ebbinghaus.

The purpose of this experiment was to test the tenability of Glanzer's verbal loop hypothesis. Since the work of Glanzer and Clark cited above was a correlational study, it cannot, of course, establish causation, and it may well be that whatever it is that causes a stimulus array to be more difficult also causes it to be verbally encoded more verbosely.

The logic behind this study was that if, in fact, the mechanism of the reproduction of a briefly presented stimulus array is a translation of a brief visual image into a more permanent verbal record, then not only should mean verbalization lengths of individual stimuli correlate highly with stimulus difficulty as measured by the number of errors per stimulus, but variability in subject accuracy across all stimuli presented should be accountable in terms of mean verbalization length per S.

Specifically, the independent variable in this experiment was the pattern of an eight-digit binary number, and the dependent variables were verbalization length in units of words and stimulus difficulty in terms of number of errors.

There were two major objectives to this experiment: (1) to replicate Glanzer's findings, thereby establishing that the method and data herein are compatible with his work; and (2) to go a step beyond his experiment and test the ability of the verbal loop hypothesis to predict individual differences by correlating mean number of errors per S over all stimuli with mean verbalization length per S over all stimuli.

SUBJECTS

The Ss were two groups of Hofstra University evening students. Group 1 consisted of students in E's course in physiological psychology and Group 2 consisted of students in E's introductory psychology course.

APPARATUS

The 20 eight-digit binary numbers used as stimuli in this experiment were typed on 2 x 2 in. translucent plastic slides using IBM Courier 72 10-pitch type on an IBM selectromatic typewriter and projected by a 500-W Sawyer Model 500 projector onto a projection screen located at the front of a lecture hall, approximately 15.5 ft in front of the projector. A Lafayette tachistoscopic shutter was mounted in front of the projection lens and was used to control stimulus exposure time. Table 1 describes the 20 binary numbers used as stimuli and shows their order of presentation, which was selected randomly.

PROCEDURE

Both groups were told that they were going to be shown a set of eight-digit binary numbers for a brief period of time and that they were to reproduce the number shown on a numbered answer sheet provided as soon as the display went off. Immediately prior to the presentation of each display, the E said "ready" to alert the Ss. Stimuli were displayed for 0.5 sec, and the Ss were then given 20 sec to write down their responses. The 20 different stimuli were presented twice in the same order, making a total of 40 responses recorded, 2 per stimulus. A 5-min rest period was given between the first and second stimulus cycle. Prior to presenting the stimuli, all Ss were given three practice trials with the first three stimuli presented reversed to assure that all Ss understood the instructions.

Following testing, the Ss were shown the original stimuli and requested to describe them in words in the answer booklets provided so that they could later reproduce the stimuli from their descriptions. This writing was done with the stimulus arrays in view. The Ss were given 1 min to describe each of the first 10 stimuli and 45 sec to describe each of the last 10.

The Ss were then asked to reproduce the original stimuli from their written descriptions. Only one S had to be discarded because he made more than one

Table 1
Test Stimuli

Stimulus Number	Stimulus	Decimal Equivalent
1 (21)	01100001	97
2 (22)	11101000	232
3 (23)	01000111	71
4 (24)	11110000	240
5 (25)	11111111	255
6 (26)	01000100	68
7 (27)	00000000	0
8 (28)	10011001	153
9 (29)	00110011	51
10 (30)	00011000	24
11 (31)	01111011	123
12 (32)	00001100	12
13 (33)	11011011	219
14 (34)	00110001	49
15 (35)	01010101	85
16 (36)	01110000	112
17 (37)	11001000	200
18 (38)	01110101	117
19 (39)	00011101	29
20 (40)	10001111	143

*This work was done under the auspices of Dr. Coleman Paul of Adelphi University.

Table 2
Stimulus Difficulty vs Mean Stimulus Verbalization Length

	ρ	r	p
Group 1	.7888		<.01
Group 2	.6572		<.01
Combined Group		.8491	<.01

error in reproducing the original 20 stimuli from the verbal descriptions.

In addition to the foregoing, Group 1 was requested to write verbal descriptions for the first 10 stimuli which were reversed prior to testing to provide a measure of reliability of the measurement of verbalization length as a characteristic of an S.

RESULTS

The mean of the verbalization lengths for the 10 pretest stimuli used in Group 1 was 13.46 words and the mean of the posttest verbalization lengths for the 20 test stimuli used for the same group was 10.26 words. However, while the posttest verbalization length tended to be shorter, the Ss tended to maintain a constant relative position within their group with respect to verbalization length. Thus, the pretest and posttest scores per S had a product-moment correlation of .7011, which was significant below the .01 level of confidence. The mean verbalization length per S was computed by counting all words and symbols used.

From the foregoing it can be seen that the measure of mean verbalization length as a characteristic of an S has been demonstrated to have a moderate degree of reliability.

Rank-order correlation coefficients for stimulus difficulty, as measured by total number of errors per stimulus and mean verbalization length per stimulus in words, were computed individually for Groups 1 and 2, and a Pearson r was computed for the combined group.

The results shown in Table 2 generally replicate the results reported by Glanzer and Clark. Stimulus difficulty scores for the first and second exposures of the 20 test stimuli were compared for both groups, and the results are summarized in Table 3.

Table 3 shows that the mean stimulus difficulty decreased on the second run, indicating a practice effect that would tend to lower the correlation between stimulus difficulty and verbalization length per stimulus, which the verbal loop hypothesis predicts, because the number of errors per stimulus is a function both of its intrinsic difficulty and its serial position. However, the correlation between the first and last 20 stimuli shows that the individual stimuli tend to hold the same relative difficulty positions on the second run, and hence it is reasonable to compute stimulus difficulty by adding the total number of errors on both presentations.

An analysis of the methods of verbal encoding used by the Ss reveals that 35 Ss used runs of zeros and ones, 2 translated the symbols directly into decimal numbers, 12 reported groupings of decimal numbers, 9 employed straight translation into a chain of eight ones and zeros, and only 3 used some power or repeat notation.

In addition, six Ss misunderstood the prohibition against the use of numerals to proscribe the use of the words one or zero, hence they encoded these with different words, e.g., sticks and circles. Three Ss compulsively gave alternative encodings for the same stimulus, and only their first description was counted. Twenty-nine Ss used only one method of encoding, and 22 Ss alternated between two or more methods.

An inspection of the data gives the impression that on this particular experimental task there is no characteristic method of encoding used by Ss who tend to score high or low on accuracy of stimulus reproduction.

Table 4 shows rank-order correlation coefficients for total S errors vs mean S verbalization length for Groups 1 and 2 and a product moment coefficient for the combined groups. Table 4 shows the complete absence of the relationship between individual ability on the experimental task and characteristic verbalization lengths of individual Ss that was predicted by the verbal loop hypothesis, in spite of the fact that the same data replicates the relationship reported by Glanzer and Clark between stimulus difficulty and characteristic stimulus verbalization length.

Table 3
Stimulus Difficulty Scores on First and Second Presentations

	Group 1 (N = 35)			Group 2 (N = 16)		
Mean stimulus difficulty in total number of errors / 20 stimuli	$S_{1\text{-}20}$	$S_{21\text{-}40}$	Total	$S_{1\text{-}20}$	$S_{21\text{-}40}$	Total
	15.5	12.25	13.88	6.35	4.7	5.53
SD	7.15	6.67		2.50	2.88	
t	5.88			2.63		
df	19			19		
p	.01			.05		
$\rho_{S_{1\text{-}20}}$ vs $S_{21\text{-}40}$	.8922			.4835		
p	.01			.05		

Table 4
Total S Errors vs Mean Verbalization Length Per S

	ρ	r	p
Group 1	.0775		n.s.
Group 2	.0470		n.s.
Combined Group		-.0882	n.s.

DISCUSSION

Comparing the foregoing results with Glanzer and Clark's work cited above, it is noted that they reported an r of -.826 between stimulus accuracy and mean verbalization length, while the combined group in this experiment yielded an r of .8491 between total number of stimulus errors (the inverse of stimulus accuracy) and mean verbalization length. This is a good replication of their results and establishes that it is valid to proceed with this data and test the further prediction made in the introductory section of this paper.

The reliability of the mean verbalization length measured herein for Group 1 was .7011, as compared to Glanzer and Clark's finding of .966. One reason for this discrepancy may be the fact that Glanzer and Clark were testing the reliability of verbalization length as a characteristic of a stimulus, and here it was tested as a characteristic of an S.

Perhaps the most interesting result reported herein is the complete absence of any relationship between the individual S's ability on the experimental task and his mean verbalization length, in spite of the replication of Glanzer and Clark's results that the data yields. This would appear to indicate that the verbal loop hypothesis has not been demonstrated by showing a correlational relationship between stimulus accuracy (or difficulty, as in the present study) and mean verbalization length. However, discarding the verbal loop hypothesis completely would be to disregard a large body of experimental data cited above, which appears to demand some verbal encoding mechanism to account for the results.

Perhaps the best way to look at the results reported herein is to realize that the task of reproducing briefly presented binary numbers and the task of writing verbal descriptions of these numbers are two different tasks and there is no reason to suppose any correspondence between the types of verbal encodings used in the two tasks. This idea would appear to be confirmed by the very clear impression given by some of the written stimulus descriptions, that the effect of the instructions to "describe the stimulus so that you could later reproduce it from your description" was to produce unduly verbose descriptions to assure retrievability.

Glanzer & Cunitz (1966) provide another possible reason for the failure of the verbal loop hypothesis to predict S's ability on the experimental task. In attempting to account for the serial-position effect in free recall of a list, they assume the operation of a short-term and a long-term memory system. It may well be that in the present experiment both short-term visual and long-term auditory memory are being utilized and the effect of the former may confound the action of the latter.

The findings reported herein are in agreement with the results reported by Sang & Ross (1970) and suggest that the verbal loop hypothesis may require modification and further testing.

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Recognition reaction time and size of the memory set: A developmental study*

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Kindergarten, fourth-grade, and college Ss were tested on a recognition reaction-time task with memory sets of two, three, and four items. Though overall reaction time (RT) varied with age, the slopes of the functions relating RT to size of the memory set did not differ significantly as a function of age. Within the context of a theory of recognition memory developed by Sternberg (1966), the results suggest that young children scan memory for familiar pictures as quickly as do adults.

Sternberg (1967) has identified two processes which underlie the recognition of a stimulus as a member of a previously learned set. One is the formation of a representation of the test stimulus. The second is a memory search or comparison process in which the encoded test stimulus is compared serially and exhaustively to items represented in memory. The search is serial in that comparisons occur one at a time, and it is exhaustive in that the encoded test stimulus is checked against every item in the memorized set.

The temporal parameter of the search process is the slope of a linear function which relates reaction time (RT) of the recognition response to size of the memory set (Sternberg, 1963, 1966). The slope describes the rate at which memory is searched, i.e., the time required for each comparison. The intercept of the function is a composite measure of the times taken by other processes which precede and follow the search, including the time for stimulus encoding. Indeed, Sternberg (1967) has demonstrated that when S is shown a visually degraded test stimulus, additional time is required prior to memory search for transforming the stimulus into a usable representation. After a session of practice, degrading the test stimulus was found to increase the intercept of the RT-set size function but not to change its slope.

Sternberg's theory and procedures are potentially useful for understanding differences between the RTs of children and adults. Why do children react more slowly? The longer RTs may reflect slower memory search, slower perceptual and motor processes, or a combination of effects. The present investigation examines RT as a function of set size for children and adults.

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SUBJECTS

There were 54 Ss, nine males and nine females from kindergarten, fourth-grade, and college classes. Only students of ages appropriate to their grade levels were tested.

STIMULI AND TRIALS

The stimuli were line drawings of 27 highly familiar objects (e.g., hammer, dog, shirt) and were divided randomly into three groups of nine. Each stimulus group was further subdivided into sets of two, three, and four elements such that any subset could be designated as the positive memory set, with remaining elements negative. Nine additional drawings were used in pretraining and practice. Slides of each picture were prepared for presentation as test stimuli. Projected slides appeared as 4 x 6 in. white-on-black line drawings. The stimulus pictures were also printed on 5 x 8 in. cards, which were used to teach Ss the membership of memory sets.

Two experimental sessions were each divided into three blocks of trials. Prior to a block of trials, S was shown a memory set of two, three, or four stimuli. A trial block consisted of sequentially presented test stimuli. The S's task was to respond positively to a test stimulus if it was in the memory set and negatively if it was not. There were 4 warm-up and 18 test trials in a block: one-third of the test trials were positive and two-thirds were negative. For a given S the three trial blocks in a session were each associated with a different group of nine stimuli and a different size of memory set. The order of testing each set size and the group of stimuli associated with each set size were counterbalanced across Ss for Day 1. On Day 2 each S received the same trial blocks as on Day 1, but in reverse order.

APPARATUS

Slides were rear-projected on a milk-glass screen located 2 ft from S at eye level. An auditory signal provided a 1-sec warning in advance of each test slide. Onset of a slide started a timer which recorded RTs to the nearest millisecond. Slide and timer were simultaneously terminated by S's response on a two-key response panel. A feedback display located to the left of the screen operated automatically to present a reward light when S responded both correctly and quickly. To be rewarded, fourth-grade and college Ss were required to respond within .85 sec, and kindergarten Ss had to respond within 1.05 sec. Slides were programmed to occur at a rate of one per 5 sec.

PROCEDURE

On Day 1 kindergarten and fourth-grade Ss were given simple RT training before the recognition task was explained. Each child was taught, first with the right hand and then with the left, to respond within