AN EXPERIMENTAL STUDY of the INFLUENCE OF COLOR on the PAIRED-ASSOCIATE LEARNING AND RETENTION OF NONSENSE SYLLABLE RESPONSES TO INKBLOT STIMULI

SMITH - 1952

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THESIS SUBMITTED FOR THE DEGREE OF MASTER OF SCIENCE

UNIVERSITY OF MASSACHUSETTS

JUNE 1952

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EXPERIMENTAL AND THEORETICAL BACKGROUND

Clinical observations have suggested that the color, shading, and form of Rorschach inkblots are among the stimulus variables which influence intra-individual and inter-individual differences with respect to various reaction categories. Recently, there has been heightened interest in the experimental exploration of the significance of these cues as response determinants. Notable in this respect are the reports on the differential effects of chromatic and achromatic blots on reaction times and response productivity by Siipola and her collaborators (18,19), Lazarus (12), and Dubrovner, Von Lackum and Jost (7). These studies have led to the formulation of the problem of this study, namely, the investigation of the learning and retention of paired-associate nonsense syllable responses to inkblot stimuli as a function of color.

The present investigation was developed primarily within the procedural and conceptual framework of the psychology of learning rather than in terms of Rorschach research *per se*. Therefore, relevant experimental findings concerning the effect of color on learning and retention will be summarized before turning to a brief consideration of relevant aspects of the above studies.

The Effects of Color on Learning and Retention.

The role of color as a determinant of the degree of learning and/or of retention of stimulus materials has not been investigated extensively. In an early study Achilles (1) compared the relative effect of different colors, (red, yellow, blue, and green) on recall and recognition. Her findings indicated that syllable color was not related to the number of syllables recalled or recognized. Subsequently, in an investigation of "the extent to which form and color united in the same figure have mnemonic independence" Pialat (14) presented a number of nonsense words paired with black forms, colored forms and colored circles. The Ss task was the reproduction of the nonsense words associated with the various colored and uncolored forms. The results of a series of tests indicated that color was significant determinant of the degree of reproduction only when combined with numerous and novel figures or when the forms were similar.

Brandt (4), who was concerned with the role of color in advertisements, attempted to test the hypothesis "that color does somewhat guide a selective functioning of memory" (4, p. 45) by comparison of the degree of retention of four types of advertisement layout involving three uses of color. One type of advertisement was in color. The trademark only was in color for the second type. The third and fourth types were advertisements in which only the background was colored and which were entirely uncolored, respectively. Retention of the advertisements was measured in three ways: pure recall, aided recall, and recognition. The results of the retention test suggested that, while color tends to raise recognition values, the manner of use of color rather than color *per se* was the more significant determinant of amount retained. Of the four colors used, rank orders for combined memory value were red, as most readily remembered, green, yellow, and blue.

In a study reported by Van Buskirk (21), control Ss learned a list of nine black syllables on white while Ss of the experimental group were given eight black-on-white syllables plus a ninth in red on a green background. For the experimental Ss the serial position of the colored syllable was varied from the most to the least advantageous position. When retention was tested by recall procedures it was found that, regardless of position, the colored syllable was retained better than a corresponding syllable in the control list. As a consequence Van Buskirk concluded that vividness of material was an important variable in the learning situation.

To summarize these findings, it would appear that under certain conditions of usage, color may serve to increase retention. However, since chromatic vs achromatic and/or color versus color comparisons might have involved uncontrolled variations in intensity, whether the observed effects should be attributed to color and/or to intensity differences cannot be determined.

The Effect of Inkblot Color on Reactions.

Rorschach (17) and subsequently other clinicians (2,3,15) have reported that Ss tend to respond somewhat differently to colored Rorschach inkblots than to black-and-white cards. Generally, increased reaction times and fewer responses are reported. Conversely, but less commonly, some Ss may respond more rapidly and/or with more associations.

Since Rorschach theorists have assumed that responses to inkblots reflect general underlying personality processes the observed relationships between color and reaction times and/or productivity raises two problems. The first is what general personality process is evoked with greater intensity by chromatic than by achromatic stimuli. The second concerns the nature of the relationship between the personality process and overt associative reactions. Rorschach's answer to the former problem was that "color interpretations, especially the C's and CF's are in some way related to egocentric affectivity, to unmodified, almost instinctive affectivity" (17, p. 208). Similarly, Rapaport (15) concludes the "experience tends to show that the Ss use of the colors as determinants in some way refers to his characteristic expression and control of affects, impulses, and actions" (15, p. 238). That color is related to affectivity is also expressed by Beck who holds "that color-determined responses represent the differences in Ss's emotions between turmoil and tension, and between tension and the gentler phases of human feeling" (2, p. 113). Agreement with Rorschach's notion of color responses as indices of affectivity, impulsivity, and emotional processes has also been voiced by other investigators (3,16).

These conceptions of the process evoked by color involve the further assumption that affectivity is related to reaction times and/or to response productivity. This additional assumption is an answer or at least a partial answer to the problem of the nature of the relationship between the personality process and overt responses. To comment parenthetically, the partial answer qualification was advanced because of the possibility that more complex hypotheses might be required. Thus, for example, it could be assumed that affectivity elicits an avoidance response which conflicts with the inkblot-aroused associations and thus increases reaction times and/or inhibits responses.

In the chromatic Rorschach cards, however, color occurs in combination with form, shading, intensity, and complexity. In fact, the colored cards tend to be of greater physical intensity, more complex, and of greater variation in shading. Therefore, the question has been raised, does the observed relationship between colored cards and Ss responses depend on color alone or alternatively is this relationship a function of intensity, complexity, shading or perhaps of color in combination with one or more of these additional factors? As a consequence it has been the task of the experimental psychologist to investigate the role of color as a response-determinant under conditions in which one or more of these stimulus attributes were held constant.

To this end, Lazarus (12) compared the responses of one hundred high school seniors to two sets of Rorschach cards one of which was the standard set. The other was a parallel version from which only the color had been removed. The subjects were randomly divided into two halves, one of which received the hue series and the other, the black-white set. Six weeks later each of the two groups was given the alternative set of slides. The results indicated that, with the possible exception of an increase in "popular" and the "space" responses, the absence of color had negligible effect on Ss response patterns. No evidence was found for the concept of "color shock".

A study reported by Siipola (19) has also pointed in the same direction. She prepared copies of the 20 easily distinguished details separately in two versions, one in color and the other achromatic. Two equivalent groups of college students, one of whom was given the chromatic test and the other the achromatic test, were used to compare first conceptual reactions to these matched chromatic and achromatic stimuli. It was found that the presence of color increased reaction times as well as the likelihood of the arousal of both pleasant and unpleasant emotional attitudes and also two types of influence upon the nature of the conceptual response could be distinguished. Specifically there was a weak, selective influence operating to determine response concepts to some blots and conversely a strong, disruptive influence, involving symptoms suggestive of conceptual conflict and behavioral disorganization was aroused by other blots. In her interpretation of these disruptive influences she proposed that, in comparison to achromatic blots, color blots present a fundamentally different conceptual problem for the subject. Specifically, it was assumed that the form aspect of any blot exerts the greatest or primary influence upon conceptualization. Because of Ss' extensive past experience with black and gray reproduction of objects and shapes, black-gray cards would be expected to offer a minimum of interference with the process of conceptualization based on form. Similarly when the form-suggested concept and the hue of the blot happened to be congruent the conceptual problem would remain relatively simple and there would be a minimum of interference in cases where the stimulus-hue was incongruous with the form-suggested concept (for example a purple cow) interference with the conceptual response and hence increased reaction times would be anticipated. Therefore, proceeding from this explanation of the heightened reaction times she concluded that the mere presence of color in a blot did not automatically endow it with magic affect-arousing properties, but rather that the color-form relationship had to be considered.

In the preceding study Siipola attempted to determine whether color would have measurable effects which would show up as intergroup differences. Subsequently she and her collaborators (20) attempted to measure the influence of color upon intra-individual reactions. In this study two series of chromatic and achromatic blots were presented to the Ss of the experimental group. A control group was given the same series of achromatic blots in two successive sessions. Since all other conditions, including the memory variable, were constant for the experimental and the control groups it was presumed that differences in the responses of the two groups could be attributed to the color factor. No difference between the two groups with respect to decrements in reaction times from the first to the second series were found. To account for this finding it was suggested that because of the introduction of a memory factor the method of successive presentation of chromatic and achromatic stimulus cards was not suited to the measurement of reaction times.

The data also indicated that the recognition process was influenced by the presence of hue in the ink blots, in that later, the form of a blot was difficult to recognize if the original version of the blot had been colored. Accordingly, it was hypothesized that the presence of hue produces identifiable effects upon the nature of the memory processes. To explain these observed differences the notion was advanced that colored blots leave such amorphous memory traces that it was difficult to recognize the blot later in achromatic form. Conversely achromatic blots were presumed to leave clear memory traces which were readily recognizable in subsequent colored variations.

In a similar experiment Dubrovner, Von Lackum and Jost (7), prepared achromatic slides and presented these and the regular Rorschach cards to two groups of nurses. Their results indicated that differences in reaction times were insignificant and hence reaction time could not be considered an indicator of "color shock" and, inferentially, of affective processes.

STATEMENT OF THE PROBLEM

In general, the studies noted above have indicated that, when other stimulus attributes are controlled, color or absence of color had little relation to inter-individual or intra-individual reaction times. Or, if color had an apparent effect, the results were explicable in terms of processes other than color or color-aroused affectivity. Also, little evidence was found for the influence of color on response productivity.

It should be noted, however, that the Ss of these investigations were presumably adolescent and/or adult normals. Accordingly these data do not preclude the possibility that due to different past histories only in children and/or older neurotics and psychotics is color significantly related to reaction times and/or response productivity. A second explanation might also be advanced, namely, that in normal Ss, while color may be unrelated to reaction time and/or response productivity, other processes or indices such as rate of learning and/or amount of retention would prove to be more "sensitive" to the influence of color factors.

The present study was designed to investigate the latter explanation of previous failures to find differential effects of color on selected response processes of normal adolescent and/or adult Ss. Specifically, this investigation was concerned with the comparison of the rates of learning and subsequent degree of retention of responses to unshaded dark gray and light gray (achromatic) and red (chromatic) Rorschach-like inkblots in groups of normal undergraduate students. The blots were identical with respect to shape. None of them had internal white space and the red and light gray blots were of approximately equal physical intensities.

The following considerations were pertinent to the selection of these stimulus materials. First, the suggestion will be recalled that in previous studies failure to equate intensities of the black and chromatic stimuli may have introduced a second source of response variation. Complete control of this factor would have required the use of at least two gray series, one of which was equated with the red in terms of physical intensity while the other was matched with the red with respect to subjective brightness. Because of the prohibitive cost involved in obtaining red and gray series of equal subjective brightness it was decided to try to equate only physical intensities. Unfortunately, while the red and light gray series were of almost equal physical intensities, the reds were somewhat more intense than the grays. It was possible therefore, although unlikely, that any superiority of the red or light gray conditions could have been attributed to differences in physical intensity. Also since differences in subjective brightness were not eliminated there was the possibility that these differences might be the critical determinant of the influences of red blots.

Sharpness of contour was another factor which was not explicitly controlled. Thus, because of a greater difference in blot and ground intensities, the contours of the dark gray cards appeared to be more sharply defined than those of the light gray and red series. It is possible, therefore that contour differences might have influenced the course of learning and retention.

Clinical investigators of the Rorschach have hypothesized differential reactions to various hues, with red considered to be the most effective stimulus attribute in arousing responses in most Ss. If so, previous failures to demonstrate effects of color could conceivably be ascribed to the use of several different hues only one of which, might have influenced Ss reactions and whose influence was largely outweighed or possibly counterbalanced by the presence of other hues. In order to maximize the possible effects of color, only red inkblots were employed in the present study.

In addition to intensity, both the chromatic and achromatic series of blots utilized in prior studies were confounded with shading and intra-blot white space factors. How these factors might have affected the results could not be specified. Accordingly, this source of variation was eliminated by constructing blots which were unshaded and had no intra-blot white space.

It should be noted that the inkblot stimuli of the present study were projected on a screen for groups of Ss rather than administered by the usual clinical procedure of card presentation to single Ss. This technique has often been followed in administering group Rorschachs. At present there is little evidence regarding differential influence of mode of presentation on responses.

Turning now to the problem of the derivation of hypotheses concerning the influence of color on retention, it will be recalled that Rorschach theorists have assumed that color arouses an affective state which either directly or indirectly through avoidance response arousal inhibits the evocation of associative reactions. While these assumptions are relevant to the explanation of the inhibition of previously established associations they have not been explicitly extended to and do not necessarily hold for situations which involve the acquisition of new associations. Thus, it would appear possible that, depending on the nature of future refinements of these assumptions, their extension to learning and retention situations might lead to different and conflicting predictions. For example, the affective process presumably evoked by color might be conceived as a drive state. There is evidence which suggests that medium levels of drive increase the rate of learning of complex responses (5). Therefore, if red arouses a drive state of medium intensity and granting the additional assumption of no initial relationship between the affective process and the response-to-be-learned, more rapid learning and higher retention with red than with the achromatic blots would be anticipated. Alternatively, if it is postulated that the affective state arouses an avoidance response which inhibits old associations, it would appear probable that the avoidance responses would also interfere with the acquisition of new associations. Therefore, less rapid learning and poorer retention of responses to red would be predicted.

Because of the lack of precise quantitative information concerning the influence of various stimulus attributes on response strength, the present framework of general learning theory also does not permit unequivocal predictions. Thus, Hull's stimulus intensity dynamism (11) apparently generates the hypothesis of more rapid and approximately equal learning of responses to the red and light gray blots than of responses to the dark gray cards. To complicate the predictive problem, however, learning of different responses to several similar stimuli involves stimulus generalization and differentiation. Stimulus intensity presumably increases the amount of generalization. Further greater generalization apparently retards learning (9). Therefore, it is conceivable that given relatively similar stimuli, more intense stimulation might slow down the acquisition of new responses. Dollard and Miller's (6) related notion of drive strength as a function of stimulus intensity leads to a similar predictive impasse.

In view of the fact that these shortcomings of data and/or theory substantially preclude the derivation of consistent hypotheses, it seemed more feasible to conceive of this study as of empirical import only. That is, this study was not considered a test of theory but rather as an attempt to obtain data which might suggest further investigations as well as prove to be of some ultimate relevance for later theory-construction.

EXPERIMENTAL METHOD

Subjects

Ninety-eight undergraduate students from the course in introductory psychology at the University of Massachusetts served as Ss. These Ss, whose names had been obtained by asking for classroom volunteers, were randomly assigned to one of nine experimental conditions. Originally twelve Ss were assigned to each of the nine conditions and the groups were matched with respect to sex. However, the elimination of three Ss because of color-blindness and of others because of failure to keep appointments reduced the size of the two groups to eight and of two other groups to eleven. However, the proportion of males and females within these groups remained relatively equal. The Ishihara cards were used to test for color blindness.

Stimulus Materials and Apparatus

Learning was carried out by the paired-associates method. Three sets of eight red, eight light gray, and eight dark gray Rorschach-like inkblots were the stimuli of the paired associates. Each trio of red, light and dark gray cards of the same shape was paired with one of Glaze's nonsense syllables of 100 per cent association value. The eight syllables were selected according to rules outlined by Hilgard (10).

In order to equate blot characteristics other than color it was necessary to obtain blots without shading and internal or intra-blot white space. As an additional consideration it was desired to keep Ss naive with respect to the Rorschach cards. Accordingly, similar but new inkblots were constructed by the following procedure:

1. One hundred blots were produced by dropping black poster ink on $9\frac{1}{2}$x$12\frac{1}{2}$ charcoal drawing paper in various ways and then folding the paper to make a symmetrical design.

2. Forty-five cards with symmetrical blots were then selected and used as a guide for cutting black or red construction paper in such a manner as to make two sets of red and black blots. These blots were then pasted on 7 x 7 inch white cards.

For the present study eight of these forty five inkblots with no intra-blot white space were selected, photographed and made into red, light gray and dark gray sets of 2 x 2 inch Kodachrome slides.

A Keystone overhead projector with a shutter attachment which was calibrated to allow a second exposure interval was employed to project the blots on a 5 x 7 foot beaded screen. With some inter-blot variation, the resultant images were approximately 42 inches high and 29 inches wide. A magazine arrangement for presenting one slide at a time was added to the slide platform of the projector.

In order to realize the stipulation of equal physical intensities for the red and light gray series, several light gray series were prepared. The intensities the most similar red and light gray series were measured by means of a Weston Photronic Foot-Candle Meter, Model 614. In obtaining these measurements the photometer was placed about five inches in front of the screen and in the middle of the projected images. The light source was 17 feet away. In the darkened room employed for projection, mean intensity values for the red and light gray series were 1.1 and 0.9 foot-candles respectively.

See appendix for intensity values obtained under other conditions.

Thus, while of approximately equal physical intensity, a measurable difference still existed. Under the same conditions the dark gray blots had a mean intensity of approximately 0.2 foot-candles.

Procedure

Learning - The general experimental situation has been diagrammed in Figure 1. At the beginning of the experiment Ss were assigned to seats arranged in two rows placed in arcs at a radius of approximately seven and ten feet from the center of the screen. In order to minimize distortion arising from the use of the beaded screen the maximum radial angle on either side of a line perpendicular to the center of the screen was approximately 30°.

The experiment was conducted in the early evening in a room which was equipped with black shades. The shades were drawn and the room was essentially dark except for light coming from the projector, two ordinary gooseneck lamps with 60 watt bulbs and a small 60 watt table light. The positions of these light sources are indicated in the diagram.

Nine groups learned paired associate responses to the inkblot stimuli. The eight dark gray inkblot stimuli were administered to three of these groups until a criterion of mastery of the learning task of 90 percent correct anticipations of the syllables on a single trial for each group as a whole was attained. Three groups learned to associate the same nonsense syllables to the light gray blots while the remaining groups learned to make the same syllable responses to the red blots. The 90 percent criterion was also used for these groups.

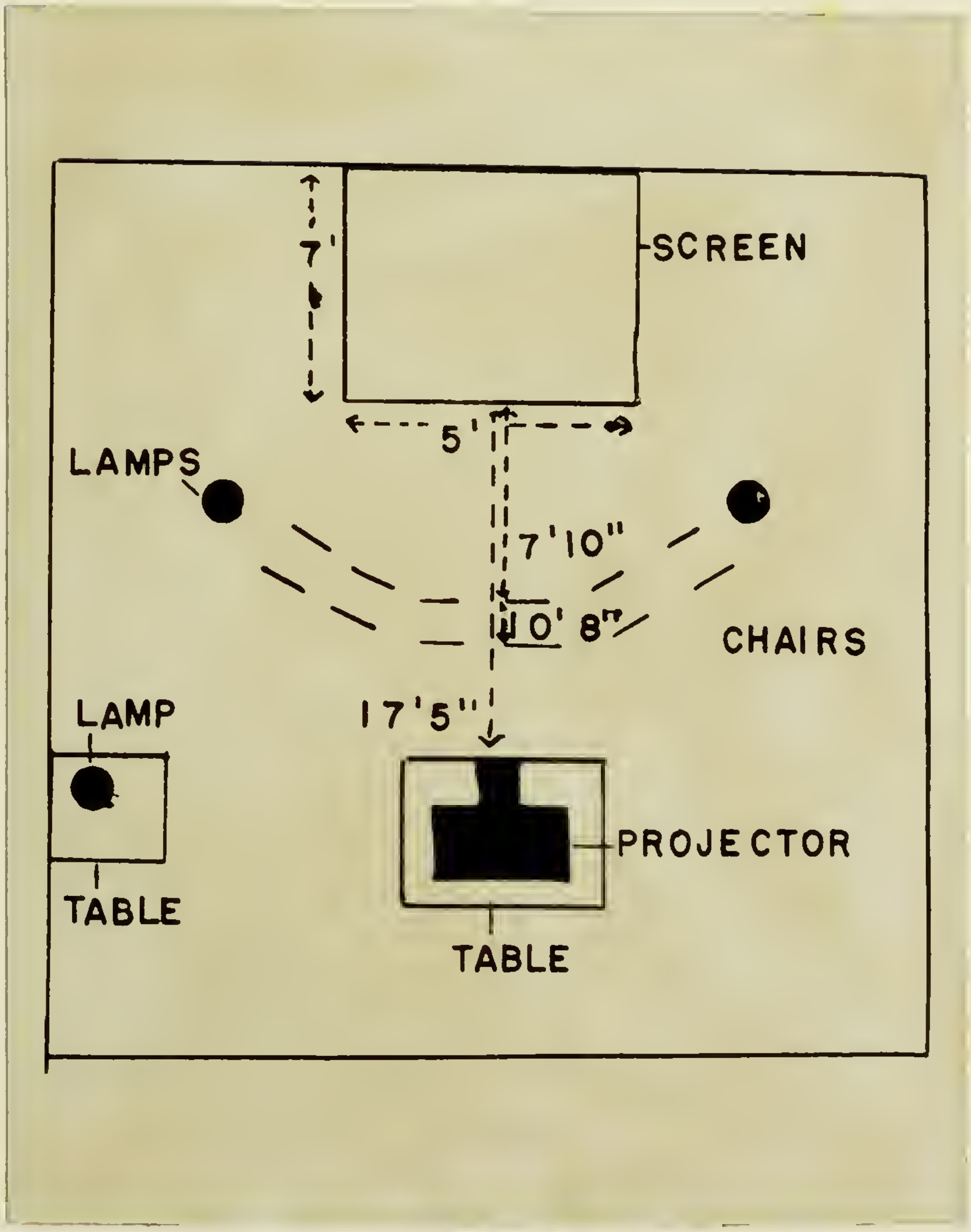

Fig. 1

Diagram of the experimental situation.

The use of an achievement criterion for the groups as a whole departed from the usual procedure of setting criteria of mastery for individuals. This procedure was adopted because projection of the inkblots permitted running groups instead of individuals. To set individual criteria for Ss in these groups would have entailed the difficulty that retention intervals would vary for individuals within each condition. Therefore, setting a group criterion assured a constant retention interval for all Ss of a given group.

Each learning trial consisted of two phases. The first was the serial presentation of each of the blot stimuli simultaneously with its paired nonsense syllable for two seconds. The simultaneous exposure of blot and word was possible because the appropriate syllable had been hand-printed on each slide. Successive slides were pushed into the projection aperture with an inter-stimulus interval of approximately two seconds. Two to four seconds after the completion of the first phase the second or association test phase was initiated. During this phase the nonsense syllables were concealed and the blots alone were exposed for two seconds. There was a two second inter-blot interval. At the beginning of the experiment Ss had been given booklets of answer sheets with blank spaces for writing the paired associate of each blot. Subjects were required to write the name of the appropriate paired-associate of each blot as the blots were exposed. Immediately after the trial the sheets were torn from the booklet and handed to E's assistant who scored correct anticipations as the next trial was progressing. Since this scoring procedure precluded E's knowing that criterion had been reached until during the first post-criterion trial all groups were carried beyond the criterion of 90 percent correct anticipations for the group as a whole.

In order to minimize serial learning four random orders of the same eight blots were prepared. These four orders were then randomly presented from trial to trial. However the same one of the four orders employed for the first phase of a given trial was also used in the second phase.

Before the first learning trial _Ss_ were given the following instructions which were to be read silently along with _E_.

> This is a learning experiment and not an intelligence, aptitude, or personality test. We are interested in the reactions of groups as a whole rather than in your personal reaction.
>
> You will be shown a group of inkblots, each one paired with a word. Study these pairs so that when an inkblot is shown alone, you can write the appropriate word. You will be shown only one pair at a time. Do NOT try to learn these pairs in any particular order, because the order will be changed every time. The point is, to associate a particular word with the inkblot with which it always appears.
>
> After every presentation of the forms paired with words, you will be shown the forms by themselves in order to see whether you remember the appropriate word or not. If you do remember it write it in the blank provided, being sure to put it in the proper space. Do _NOT_ leave any blank spaces; if you do not remember the proper word, draw a line through the space. After we have finished one of these test trials, you should tear the scoring sheet from your

> booklet, and hand it to the experimenter's assistant. Be sure to enter your name and seat number on the new scoring sheet.
>
> Are there any questions?

Retention - The retention intervals which were used for the red light and dark gray conditions are summarized in Table 1. During the 10, 30 and 60 minute rest intervals between the learning series and the retention test Ss in each group were required to read and to take notes on Chapter 12 in Vaughan's Personal & Social Adjustment.

After the 10, 30, or 60 minute interval had elapsed retention was first measured by presenting the inkblot stimuli alone and requiring the Ss to again write out the appropriate paired associates.

Prior to this recall trial Ss read the following instructions along with E.

> Now, I want you to look at some of the inkblots as they appear and put down the word for each one whenever you can. You will be shown the forms by themselves; try to write the appropriate words, just as you did in the test series. You may not remember them all the first time, but you will be given another chance later.

Subsequent to the recall test, two relearning trials were administered. These trials were presented with the same instructions and procedures as had been employed during original learning.

Nine evenings were required to complete the experiment. Table 2 depicts the order in which the various color-retention interval combinations were administered. Specifically the conditions in the first row were completed first, then those in the second row. Finally the third row conditions were run.

Table I

Summary of Retention Intervals for the Red and Two Gray Conditions.

	Retention Intervals		
Condition	10 Minutes	30 Minutes	60 Minutes
Red	X	X	X
Light Gray	X	X	X
Dark Gray	X	X	X

Table 2

Summary of the Order of Presentation of the
Nine Color-retention Interval Combinations in Three Successive Cycles
of Three Days Each for a Total of Nine Days

Cycles	Days 1		Days 2		Days 3	
I	Red	10	Light Gray	30	Dark Gray	60
II	Light Gray	60	Dark Gray	10	Red	30
III	Dark Gray	30	Red	60	Light Gray	10

RESULTS

<u>Acquisition</u> - The number of trials and means and standard deviations of correct and incorrect anticipations to criterion and of correct and incorrect responses during the combined criterion and post-criterion trials for each of the nine experimental groups have been summarized in Table 3. Also presented are the means for the three red, the three light gray and the three dark gray groups combined. Figures 2 and 3 are graphic representations of the number of trials and number of correct responses to criterion, respectively, for each of the red, light gray and dark gray groups and for the combined color combinations.

Analysis of variance was used to test the hypothesis of no differences among the nine group means (8). The resultant F of 6.80 (Table 4) for 8 and 89 degrees of freedom was significant at beyond the one per cent level of confidence. Accordingly, it would appear that the observed differences among conditions probably did not arise as the outcome of chance factors alone. Analysis of variance was also employed to test the hypothesis of no differences among the means of correct responses of the three red, the three light gray and the three dark gray conditions considered separately. The obtained F- values (Table 5) failed to reach the five percent level of confidence. Because observed differences among the means of groups which had learned to respond to the same color were not significant the three red, three light gray, and three dark gray groups were pooled to compute the three combined means of correct responses to criterion.

Table 3

Number of Trials to Criterion, Means and Standard Deviations of Correct and Incorrect Responses to Criterion, Means and Standard Deviations of the Combined Criterion and Post-Criterion Trials for the Nine Experimental Groups.

Condition	N	Number of Trials to Criterion	Correct Responses to Criterion		Incorrect Responses to Criterion		Correct Responses in Criterion and Post-Criterion Trials		Incorrect Responses in Criterion and Post-Criterion Trials	
			M	SD	M	SD	M	SD	M	SD
Red 10	8	6	29.75	10.02	18.25	10.02	14.75	2.95	1.25	2.95
Red 30	12	6	29.00	8.96	19.00	9.44	14.50	3.23	1.50	3.22
Red 60	11	5	21.82	6.13	18.18	6.13	14.45	2.27	1.55	2.27
Light Gray 10	12	5	21.50	7.94	18.50	3.90	14.67	2.78	1.33	2.78
Light Gray 30	8	3	11.11	4.71	12.89	6.90	14.75	1.20	1.25	1.39
Light Gray 60	12	6	29.75	6.76	18.25	6.79	14.67	2.24	1.33	1.03
Dark Gray 10	12	4	20.50	5.25	11.50	5.25	14.67	2.13	1.33	2.14
Dark Gray 30	11	4	20.00	5.92	12.00	5.92	15.90	2.01	0.10	2.02
Dark Gray 60	12	5	18.08	6.76	21.92	6.76	14.58	1.31	1.42	1.32
Combined Red	31	5.6	26.64	9.12	18.00	8.59	14.54	2.85	1.41	2.84
Combined Light Gray	32	4.6	22.00	9.92	15.75	6.75	14.19	1.16	1.31	1.94
Combined Dark Gray	35	4.3	19.51	6.16	15.23	7.71	15.97	1.86	1.22	2.12

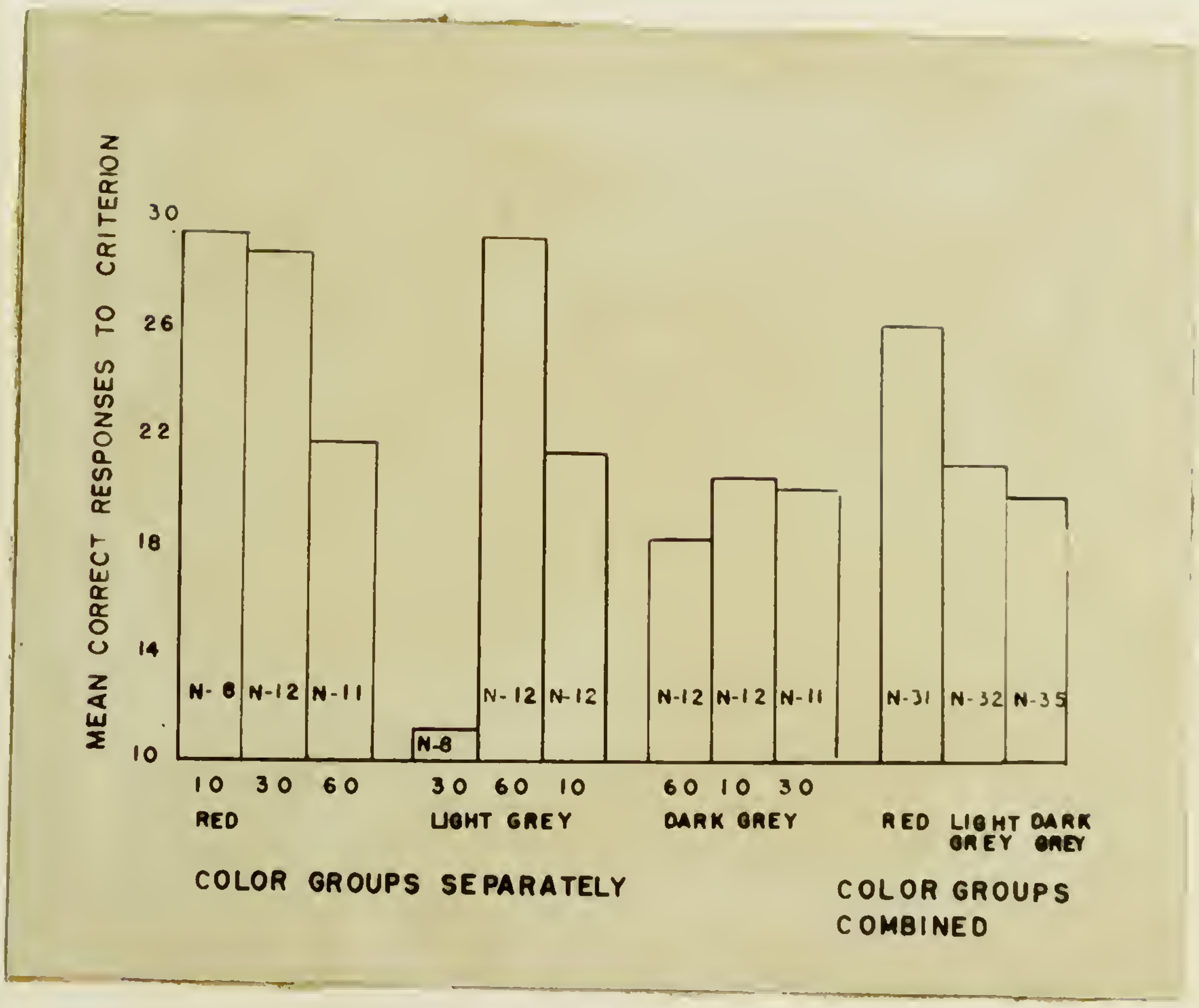

Fig. 2

Mean Correct responses for the three red, the three light gray and the three dark gray groups and for the combined color conditions.

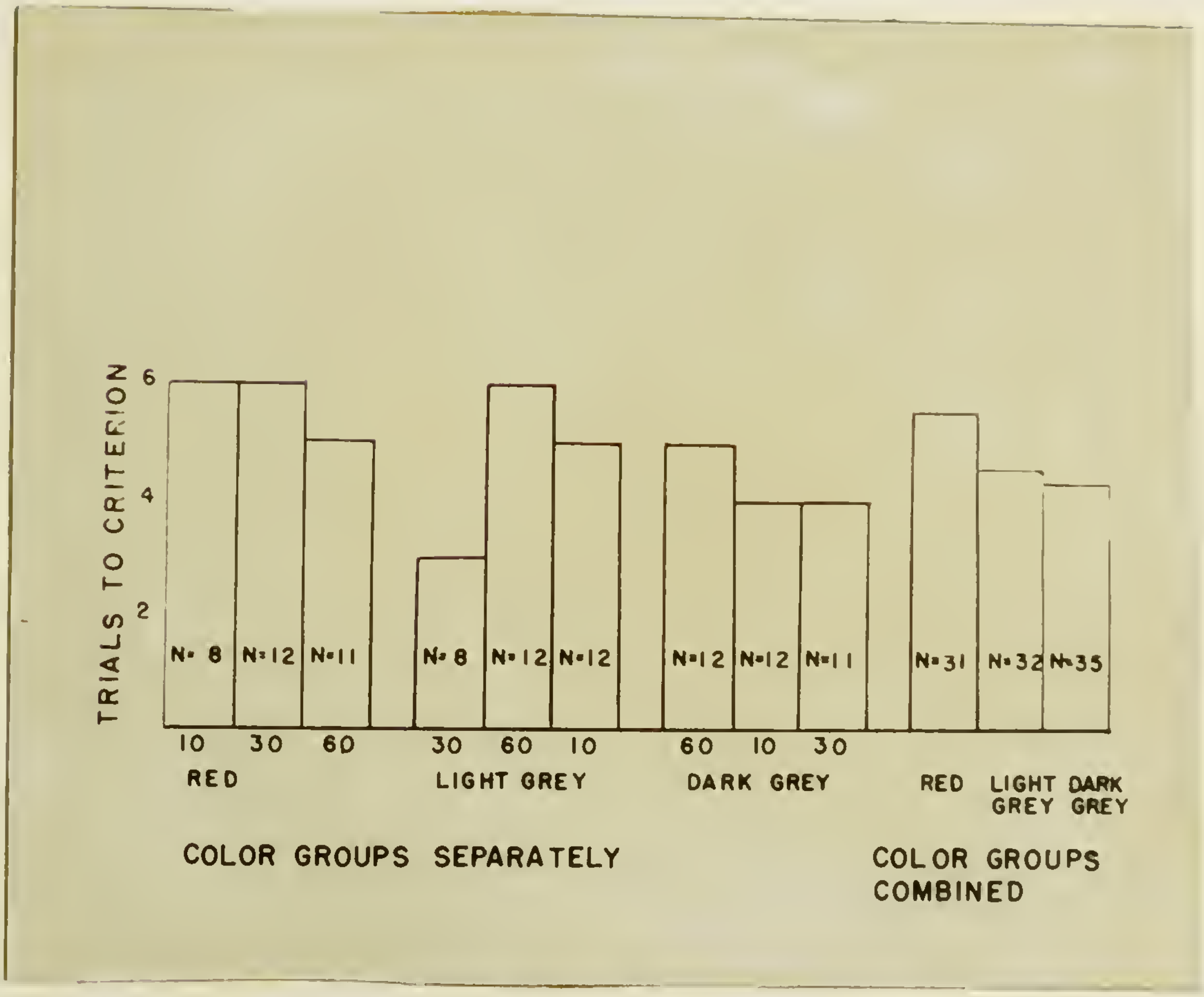

Fig. 3

Number of trials for the three red, the three light gray, and the three dark gray groups and for the combined color conditions.

Table 4

Summary of Analysis of Variance for Mean Correct Responses to Criterion for the Nine Experimental Groups

Source of Variation	*df*	Sum of Squares	Mean Squares	*F*	*P*
Between groups	8	2980.66	372.58	6.80	$< .01$
Within groups	89	4870.19	54.72		

Table 5

Summary of Analyses of Variance for Mean Correct Responses to Criterion for the Three Red, the Three Light Gray and the Three Dark Gray Conditions Considered Separately.

Condition	Source of Variation	df	Sum of Squares	Mean Square	F	p
Red	Between groups	2	399.96	199.98	0.26	>.05
	Within groups	28	2181.14	778.97		
Light Gray	Between groups	2	1669.87	834.93	1.63	>.05
	Within groups	29	1485.13	512.11		
Dark Gray	Between groups	2	38.83	19.41	0.49	>.05
	Within groups	32	1265.92	39.56		

The statistical test of the significance of differences among the means of the combined color condition groups yielded an F-ratio of 4.98 (Table 6) which is significant at the one percent level for 2 and 95 degrees of freedom. As a consequence it appears tenable to conclude that Ss in the red condition, who required a significantly larger number of correct responses and correlatively of incorrect anticipations and/or errors to reach criterion, learned less rapidly than Ss in the two gray groups. While the dark gray condition was slightly superior to the light gray, this difference could have resulted from chance fluctuations in group means.

Retention - Table 7 presents the means and standard deviations of correct and incorrect anticipations on the recall trial for each of the nine color-time interval combinations. Mean correct recall responses for each color condition have been plotted as a function of time elapsed since practice in Figure 4.

Application of analysis of variance to test the hypothesis of no difference among the nine color and time interval combination means resulted in an F of 0.483 (Table 8). Because this value was not significant at the five percent level for 8 and 89 degrees of freedom it is probable that the observed differences among the nine groups resulted from random variation.

Analysis of variance was also used to test the hypothesis of no significant differences in retention among the three time intervals for each color condition. The F's (Table 9) were not significant at the five percent level of confidence. Therefore, statistical

Table 6

Summary of Analysis of Variance for Mean Correct Responses to Criterion for the Combined Red, Light Gray and Dark Gray Conditions

Source of Variation	df	Sum of Squares	Mean Squares	F	p
Between groups	2	772.93	386.46	4.98	$<.01$
Within groups	95	7358.53	7746		

Table 7

Mean and Standard Deviations of Correct and Incorrect Responses for the Retention Recall Trial and Means and Standard Deviations of Correct and Incorrect Anticipations for the Combined Relearning Trials.

		Recall				Relearning			
		Correct Responses		Incorrect Responses		Total Correct Responses		Total Incorrect Responses	
Condition	N	M	SD	M	SD	M	SD	M	SD
Red 10	8	7.37	1.65	0.63	1.65	13.50	4.58	2.50	4.58
Red 30	12	7.41	1.03	0.59	1.03	15.08	1.93	0.92	1.93
Red 60	11	7.18	1.33	0.82	1.33	15.09	1.83	0.91	1.83
Light Gray 10	12	7.66	0.75	0.34	0.74	15.08	1.98	0.92	1.71
Light Gray 30	8	7.62	0.69	0.34	0.22	15.87	0.32	0.13	0.11
Light Gray 60	12	7.50	1.94	0.50	0.87	15.84	0.37	0.16	1.23
Dark Gray 10	12	7.08	1.61	0.92	1.61	15.33	1.54	0.67	1.54
Dark Gray 30	11	7.09	1.31	0.91	1.31	15.09	1.83	0.91	1.83
Dark Gray 60	12	6.83	2.64	1.97	0.54	15.83	0.10	0.17	0.12

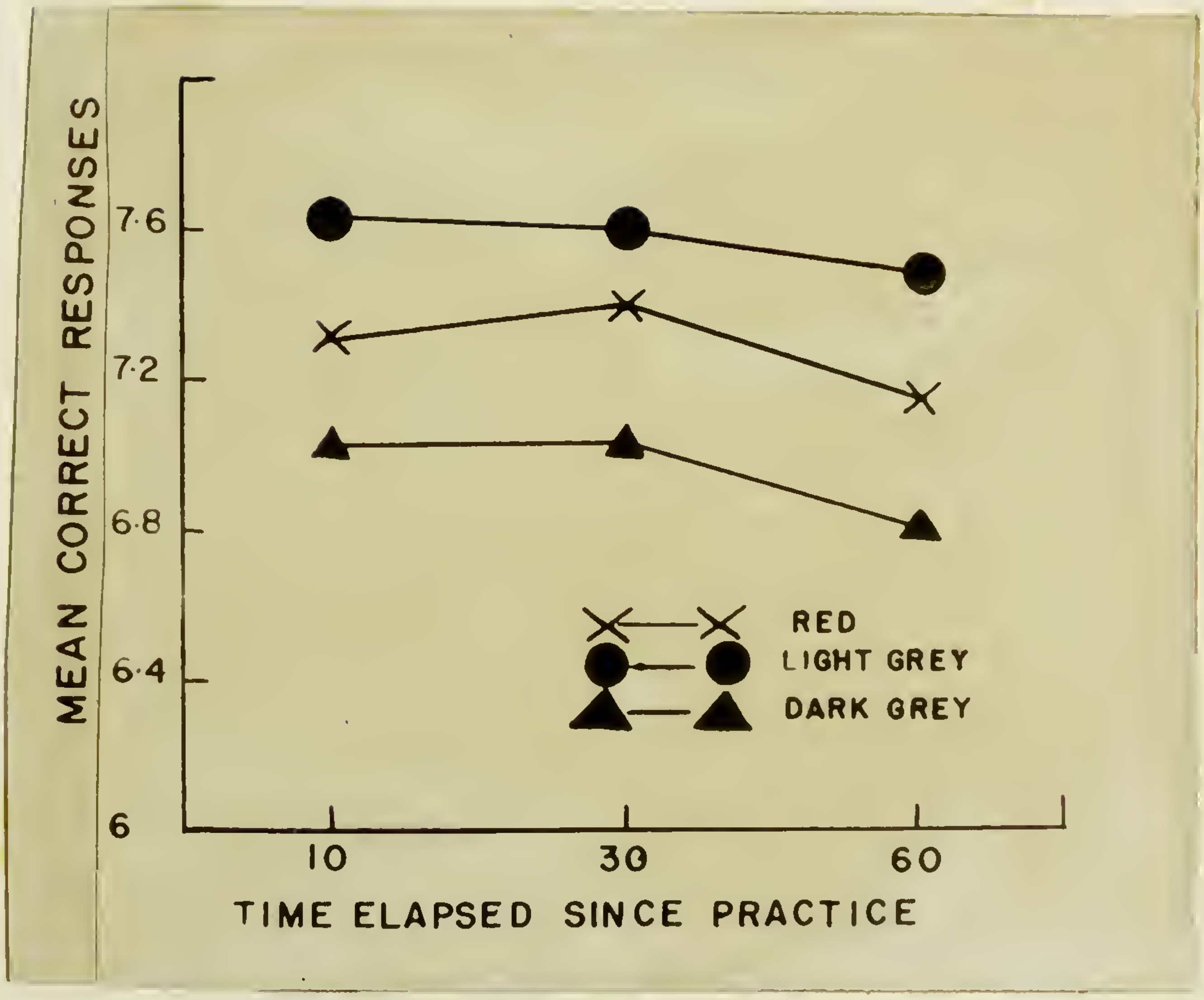

Fig. 4

Mean Correct responses for the recall trial for the three red, the three light gray and the three dark gray groups.

Table 8

Summary of Analysis of Variance for Mean Correct Responses
During the Recall Trial for the Nine Experimental Groups.

Source of Variation	df	Sum of Squares	Mean Squares	F	p
Between groups	8	6.85	.856	0.48	>.05
Within groups	89	157.57	1.77		

Table 9

Summary of Analyses of Variance for Mean Correct Responses During the Recall Trial for the Three Red, the Three Light Gray and the Three Dark Gray Conditions Considered Separately.

Condition	Source of Variation	df	Sum of Squares	Mean Squares	F	p
Red	Between groups	2	.30	.15	.07	$>.05$
	Within groups	28	56.44	2.01		
Light Gray	Between groups	2	.17	.085	.01	$>.05$
	Within groups	29	19.55	.674		
Dark Gray	Between groups	2	.42	.21	.08	$>.05$
	Within groups	32	81.58	2.55		

analysis supports the conclusion of no significant decrement in amount retained over the 60 minute retention period. The F-value (Table 10) for means of the combined color groups likewise failed to reach a statistically significant level. Hence it would appear that color is unrelated to the amount retained.

Means and standard deviations of correct responses and incorrect responses of the two relearning trials combined for each of the nine groups are summarized in Table 11. Figure 5 is a plot of the correct response means for each color as a function of time since practice.

The F-ratio of 1.12 obtained in a test of the differences among mean of correct responses for the nine groups was not significant at the five percent level for appropriate degrees of freedom. Further the F's (Table 12) resulting from comparison of the three time intervals of each color condition were not statistically significant. The F-ratio for the comparison of the combined red, light gray, and dark gray conditions also failed to reach the five percent level of significance (Table 13).

To summarize, statistical analyses of both recall and relearning data indicate that there were no differences among the nine color-interval combinations which could not be attributed to chance factors. Moreover, there were no significant differences in amount retained or relearned either for the three time intervals of each color considered separately or between the combined means of the color condition time-interval groups.

Table 10

Summary of Analysis of Variance for Mean Correct Responses During the Recall Trial for the Combined Red, Light Gray and Dark Gray Conditions.

Source of Variation	df	Sum of Squares	Mean Squares	*F*	*p*
Between groups	2	5.79	2.89	1.74	$>.05$
Within groups	95	158.63	1.66		

Table 11

Summary of Analysis of Variance for Mean Correct Responses for the Two Combined Relearning Trials for the Nine Experimental Groups.

Source of Variation	df	Sum of Squares	Mean Squares	F	p
Between groups	8	37.06	4.63	1.12	>.05
Within groups	89	366.55	4.11		

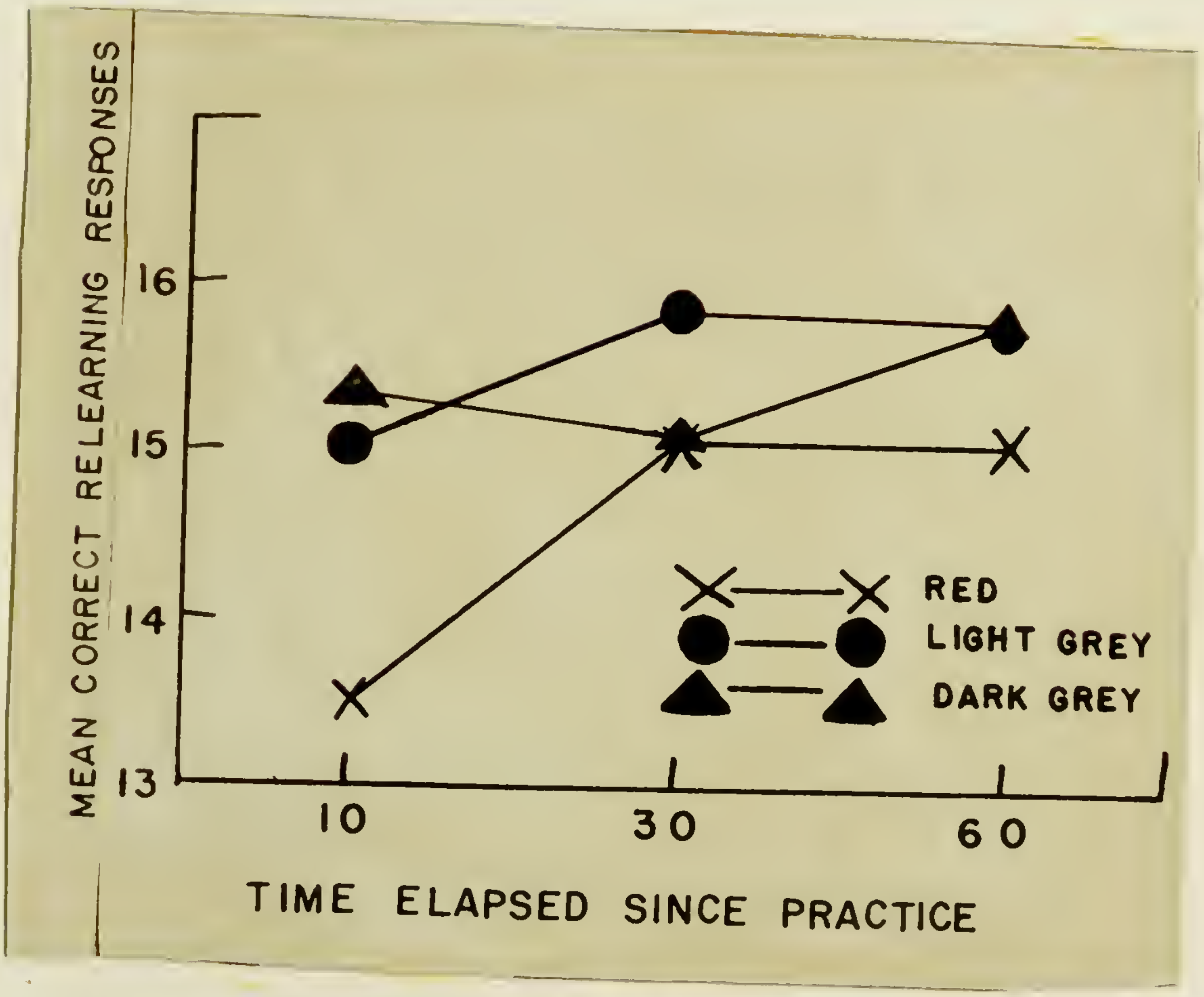

Fig. 5

Mean correct responses for the combined relearning trials for the three red, the three light gray and the three dark gray groups.

Table 12

Summary of Analyses of Variance for Mean Correct Responses for the Two Relearning Trials for the Three Red, the Three Light Gray and the Three Dark Gray Conditions Considered Separately.

Condition	Source of Variation	df	Sum of Squares	Mean Squares	F	p
Red	Between groups	2	14.95	7.47	.84	$>.05$
	Within groups	28	249.83	8.92		
Light Gray	Between groups	2	4.41	2.20	1.29	$>.05$
	Within groups	29	49.47	1.70		
Dark Gray	Between groups	2	3.33	1.66	.79	$>.05$
	Within groups	32	67.25	2.10		

Table 13

Summary of Analysis of Variance for Mean Correct Responses of the Relearning Trials for the Combined Red, Light Gray and Dark Gray Conditions.

Source of Variation	df	Sum of Squares	Mean Squares	F	p
Between groups	2	14.37	7.18	1.75	$>.05$
Within groups	95	389.24	4.09		

DISCUSSION

Acquisition - Statistical analysis indicated that the significant differences among mean correct responses to criterion for the nine groups could for the most part be attributed to the relatively slower learning of Ss in the red condition. At the present time this finding of less rapid learning of responses to red blots might be attributed to several factors acting either singly or jointly.

The first of these factors is that the red blots were less meaningful than the gray blots, and hence that responses to red were learned less rapidly. This possibility stems from the following considerations. First, Siipola found that Ss tend to respond less rapidly and with fewer associations to those stimuli whose form and color were incongrous or unusual, (for example, a purple cow). Thus in the present study the red stimuli might have evoked fewer associations than the gray cards. Second, it is assumed that the meaningfulness of a stimulus is to a large degree a function of the number of associations aroused by the stimulus (10). Third, there is experimental evidence which indicates that rate of learning and amount retained are both directly related to meaningfulness (13). Therefore if incongruity resulted in reduced meaningfulness it would be predicted that responses to red would not be learned as readily and retained as well as those to light gray or dark gray cards.

A direct test of whether or not unshaded red blots with no intra-blot white space arouses fewer associations than gray blots might be carried out by giving Ss red and gray series and comparing the series with respect to the number of associations aroused. If red stimuli did evoke fewer associations than black blots some more direct empirical evidence for this explanation would have been obtained.

Possible differences in contour either as such as acting through a mediating process of lowered meaningfulness represents a second factor. Thus the contours of the dark gray blots were somewhat more sharply defined than the contours for the light gray or red blots. While the latter blots were not compared with respect to contour by means of formal psycho-physical procedures it seemed that the light gray blots also had somewhat more pronounced contours than the reds. Therefore, granting the possibility that both the light and dark gray had more sharply defined contours than the reds it might be hypothesized that acquisition is a direct function of sharpness of contour. As such contour may have influenced learning indirectly, that is the more sharply defined contour might have evoked more associations and therefore, because of greater meaningfulness, responses to gray would be acquired more rapidly.

Greater generalization of responses to red resulting from slightly greater physical intensity (4) and hence less rapid learning to discriminate among the red stimuli represents a third explanation. However, because of the relatively slight differences in the intensities of the reds and light grays this possibility does not appear very likely. Further, the intensity difference between the light gray and dark gray stimuli was greater than that between the red and light gray, but no significant differences in the rate of learning of responses to the two grays were observed. This also suggests that intensity was largely irrelevant.

It will be recalled that while physical intensities of the red and light gray cards were approximately equated no attempt was made to use an additional series of gray cards which were judged as subjectively equal brightness with respect to the red. Therefore, there is the possibility that subjective brightness differences had a differential effect on learning rates. Specifically, since the red appeared brighter, the suggestion would be that subjective brightness retards learning.

In summary of the acquisition findings, it is suggested that the slower learning of the red group might have been occasioned by lower meaningfulness of the red stimuli, by intensity or generalization factors, or by differences between red and light gray particularly with respect to contour and/or subjective brightness. The further possibility that red or perhaps chromatic inkblots in general, retard learning cannot be dismissed. This possibility is not consistent with previous findings which suggested that if color had effects it tended to aid learning and retention. However, it is possible that the color of ambiguous inkblots has an entirely different influence on learning and retention than the effects of colored words or structured pictures.

Retention - Analysis of recall and relearning scores indicated that the observed differences among the nine color-time interval combinations were not statistically significant. Further, when differences among the means of the 10, 30, and 60 minute groups for each color were considered separately, statistical analysis suggested that there was no forgetting over the 60 minute interval. Finally there was no significant differences among the combined means of the three red, three light gray, and three dark gray conditions. Thus, under the conditions of this investigation, these data support the conclusion that at least during the first 60 minutes after the cessation of practice red stimuli do not lead either to significant increments or to significant decrements in the retention of paired-associate responses.

The failure to observe lower retention of responses to the red blots offer some slight and indirect support for the incongruity-lowered meaningfulness explanation of the retarded learning of responses to red. To be specific, it is suggested that while form-color incongruity may have retarded acquisition this factor would have been largely extinguished by the termination of learning as <u>S</u>s would have become "used to" the incongruous blots. At the end of acquisition all groups had been brought to the same performance level. Therefore if incongruity had been eliminated the nine groups would have entered the retention period on an equal basis. As a consequence no significant differences among different color conditions for the same retention interval would have occurred.

This explanation might be tested by obtaining and comparing the reaction times and/or number of responses aroused by red and gray blots both prior to and after learning new responses to the blots. Thus, using this design, if an initial superiority of gray to red with respect to reaction times and/or productivity was found prior to learning but was no longer evident after learning, it could be concluded that meaningfulness differences had been eliminated.

Attention should be called to the fact that contrary to the results of most retention studies (13) there was no measurable forgetting over 60 minutes. In this connection it will be recalled that the nonsense syllables were of 100 percent association value. In general the greater the meaningfulness or association value of syllables the greater the retention. Accordingly, it is suggested that the observed stability of anticipations over the 60 minute period can be attributed to the use of very meaningful syllables.

SUMMARY

The present study was designed to investigate the influence of color on the paired-associate learning and retention of nonsense syllable responses to sets of red, light gray, and dark gray inkblots which were the same with respect to form.

Subjects were 98 undergraduate students who had been drawn from introductory psychology courses and randomly assigned to nine experimental groups. Three color-blind students were not used.

The stimulus materials were eight trios of red, light gray, and dark gray blots which were unshaded and had no internal white space. The blots of each trio were identical with respect to form.

A Keystone overhead projector was used to project these stimuli on a screen located in a darkened room to form a 29 x 42 inch image. The physical intensities of the red and light gray images five inches in front of the screen were 1.1 and 0.9 foot-candles respectively. The dark gray blots had an intensity of from 0.2 to 0.3 foot-candles.

Learning was by the paired-associate method. The first phase of each learning trial consisted of the serial presentation of the eight blot-syllable combinations for a given color. The blots and syllables were exposed simultaneously for two seconds and there was a two second inter-blot interval. Two to four seconds after the presentation of the eight blot syllable pairs the blots alone were presented serially each for two seconds with a two second inter-blot interval. In this phase _S_s were instructed to write the appropriate paired nonsense syllable for each blot. Subjects were run in groups of from eight to twelve to a group criterion of 90 percent correct anticipations.

Each group was given one post-criterion trial. Three red, three light gray, and three dark gray blot acquisition groups were employed.

Retention of the paired associate anticipations to each color was measured after 10, 30, or 60 minutes. During the rest interval <u>S</u>s studied and took notes on a chapter from <u>Vaughan's Social and Personal Adjustment</u>. After the designated interval had elapsed, retention was measured by means of one recall and two relearning trials.

Statistical analysis of the acquisition data indicated that observed differences in mean correct responses to criterion among the nine groups three of whom had red blots, three light gray and three dark gray were significant at the one percent level. Application of analysis of variance to the combined learning means of the three color conditions indicated that responses to the red series were acquired less readily than responses to the two gray series.

The differences among the nine color-time interval recall and relearning means were not statistically significant. Also, the F's obtained in the analysis of the three time interval means of each color were not significant thus suggesting that there was no forgetting over the 60 minute retention period.

One explanation of the slower learning of <u>S</u>s under red blot treatment which was advanced involved the possible influence of incongruity of form and color. It was suggested that this factor might have resulted in a smaller number of associations aroused by red which in turn might have led to slower learning of response to red. Also considered as possible bases for the observed differences were sharpness of definition of contour, physical intensity, and subjective brightness.

With respect to the failure to obtain significant intergroup differences in recall and retention measures it was suggested that had fewer associations due to incongruity played a role in retarding the learning of responses to red, this factor would have probably been extinguished by the end of the acquisition period. Accordingly, since the initial superiority of the gray groups would have been eliminated and Ss started the retention period at equal acquisition levels, no inter-group differences in retention would have resulted.

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APPENDIX

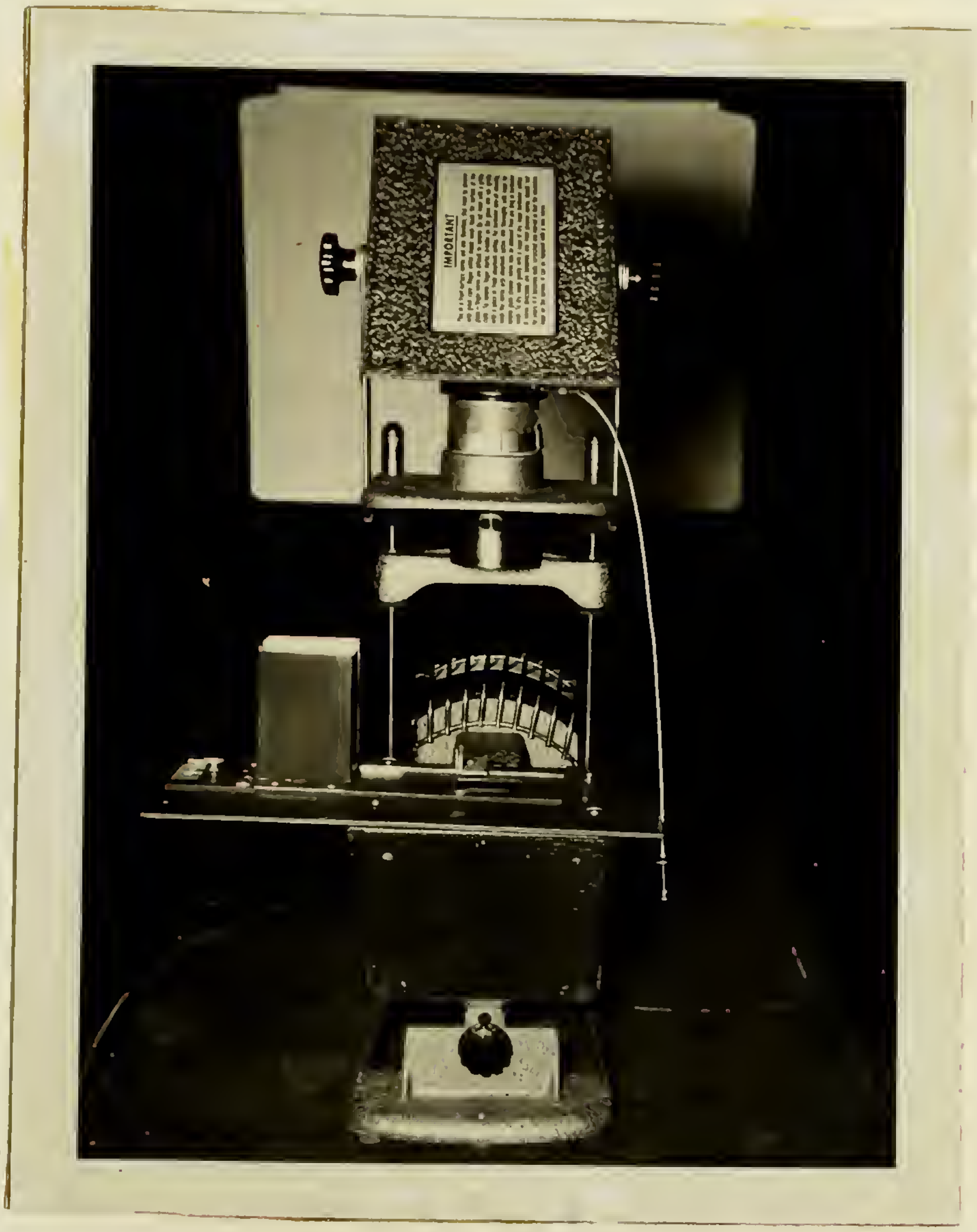

Fig. 6

Photograph of the Keystone Overhead Projector showing an adapted slide feeding mechanism.

Inkblot Stimuli and Paired Nonsense Syllable Responses.

CUS

WIF

BAL

GIV

SER

HOB

KEN

RAC

Description of other Procedures Used in Measuring Physical Intensities.

Intensity measurements were obtained with the figure alone projected on the screen, ground having been masked out. These measurements were first attempted five inches from the screen with the photometer facing the light source. However, since no readings were obtained at this distance, and in order to obtain representative readings, the instrument was placed about 1 foot and 10 inches directly in front of the light source from which the slides were projected. Mean intensity readings under these conditions for the red, the light gray, and the dark gray stimuli were 75, 45, and 5 foot-candles, respectively.

Table 14

Total Number of Correct Responses to Criterion and Total Number of Correct Responses for the Combined Criterion and Post-Criterion Trials for each S in the Three Red Conditions.

	Red Ten Minutes			Red Thirty Minutes			Red Sixty Minutes	
Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials	Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials	Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials
1	11	7	1	29	16	1	13	8
2	39	16	2	9	4	2	20	16
3	16	15	3	25	16	3	22	14
4	37	16	4	36	15	4	17	15
5	34	16	5	29	15	5	16	16
6	28	16	6	36	15	6	17	14
7	39	16	7	35	14	7	26	16
8	34	16	8	21	16	8	21	16
	238	118	9	24	16	9	34	16
			10	47	16	10	23	13
			11	28	15	11	31	15
							240	159
			12	29	16			
				348	174			
	Trials To Criterion 6			Trials to Criterion 6			Trials to Criterion 5	

Table 15

Total Number of Correct Responses to Criterion and Total Number of Correct Responses for the Combined Criterion and Post-Criterion Trials for Each S in the Three Light Gray Conditions.

	Light Gray Ten Minutes			Light Gray Thirty Minutes			Light Gray Sixty Minutes	
Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials	Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials	Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials
1	19	16	1	9	12	1	21	16
2	32	16	2	17	16	2	19	13
3	26	16	3	10	12	3	21	14
4	15	8	4	20	16	4	35	16
5	8	9	5	9	15	5	24	16
6	15	15	6	10	12	6	39	16
7	33	16	7	4	16	7	38	16
8	15	16	8	10	16	8	30	14
				89	118			
9	13	16				9	32	15
10	26	16				10	37	16
11	29	16				11	28	8
12	27	16				12	33	16
	258	176					357	160

Trials to Criterion 5   Trials to Criterion 3   Trials to Criterion 6

Table 16

Total Number of Correct Responses to Criterion and Total Number of Correct Responses for the Combined Criterion and Post-Criterion Trials for Each S in the Dark Gray Conditions.

	Dark Gray Ten Minutes			Dark Gray Thirty Minutes			Dark Gray Sixty Minutes	
Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials	Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials	Ss	Total Correct Responses to Criterion	Total Correct Responses during Criterion and Post-Criterion Trials
1	19	16	1	18	16	1	24	16
2	26	16	2	17	16	2	12	13
3	13	11	3	18	16	3	25	14
4	13	11	4	20	16	4	18	14
5	23	16	5	16	16	5	10	15
6	11	11	6	31	16	6	19	15
7	21	16	7	18	16	7	13	15
8	23	16	8	8	9	8	4	12
9	25	15	9	22	14	9	22	16
10	21	16	10	24	15	10	28	16
11	23	16	11	28	16	11	19	13
12	28	16				12	23	16
	246	176		220	166		217	175

Trials to Criterion 4 | Trials to Criterion 4 | Trials to Criterion 5

Table 17

Total Number of Correct Responses During the Recall Trial, Total Number of Correct Responses for the Combined Relearning Trials for Each S in the Three Red Conditions.

Red Ten Minutes			Red Thirty Minutes			Red Sixty Minutes		
Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials	Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials	Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials
1	3	3	1	8	16	1	5	10
2	8	9	2	5	9	2	8	16
3	8	16	3	8	16	3	7	16
4	8	16	4	8	16	4	8	16
5	8	16	5	8	15	5	8	16
6	8	16	6	8	16	6	4	14
7	8	16	7	6	14	7	7	16
8	8	16	8	8	16	8	8	15
	59	108	9	8	15	9	8	16
			10	8	15	10	8	16
			11	6	16	11	8	16
							79	166
			12	8	16			
				89	181			

Table 18

Total Number of Correct Responses During the Recall Trial, and Total Number of Correct Responses for the Combined Relearning Trials for Each S in the Three Light Gray Conditions.

	Light Gray Ten Minutes			Light Gray Thirty Minutes			Light Gray Sixty Minutes	
Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials	Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials	Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials
1	8	16	1	7	16	1	8	16
2	8	16	2	6	16	2	7	16
3	8	16	3	8	16	3	8	16
4	8	14	4	8	15	4	7	15
5	6	9	5	8	16	5	8	16
6	8	16	6	8	16	6	8	16
7	8	16	7	8	15	7	8	16
8	8	14	8	8	16	8	5	16
				61	127			
9	8	16				9	8	16
10	8	16				10	8	16
11	6	16				11	8	16
12	8	16				12	7	15
	92	181					90	190

Table 19

Total Number of Correct Responses During the Recall Trial and Total Number of Correct Responses for the Combined Relearning Trials for Each S in the Three Dark Gray Conditions.

	Dark Gray Ten Minutes			Dark Gray Thirty Minutes			Dark Gray Sixty Minutes	
Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials	Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials	Ss	Total Correct Responses during Recall	Total Correct Responses during Combined Relearning Trials
1	8	16	1	8	16	1	5	16
2	8	16	2	8	16	2	8	16
3	5	11	3	8	16	3	8	16
4	4	13	4	8	16	4	8	16
5	8	16	5	5	13	5	8	16
6	4	16	6	8	16	6	8	15
7	8	16	7	8	16	7	8	16
8	8	16	8	4	10	8	3	15
9	8	16	9	7	16	9	7	16
10	8	16	10	7	15	10	8	16
11	8	16	11	7	16	11	5	16
12	8	16				12	6	16
	85	184		78	166		82	190

Acknowledgments

It is impossible to mention in this limited space all of those among faculty, graduate students and friends who have through their unselfish interest contributed to this investigation. Likewise, it is difficult to adequately express my eternal appreciation to Dr. Albert E. Goss, for his wisdom, constant supervision, his generous gift of time and counsel which have saved me many errors and problems of form and organization. Gratefulness is also extended to Dr. Marie Boas and Dr. J. Harold Smith for their many cogent and timely criticisms and to Mr. Joseph Mach whose ingenuity and mechanical know-how made it possible to complete this study.

Last, but certainly not least, the author wishes to express gratitude to his most direct and constant helper, motivator, experimental assistant, and wife without whom there would have been no end.

APPROVED

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Date May 26, 1952