AN EVALUATION OF THE REINFORCING PROPERTIES
OF VISUAL STIMULUS CONSTRAINT

DISSERTATION

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EXPERIMENT I

INTRODUCTION

It has been shown that visual exploration of a variety of situations can serve as a reinforcement (Butler, 1953, 1954, 1957; Butler and Alexander, 1955; Butler and Harlow, 1954). These data have posed a challenge to general theories of reinforcement in that they have been presumed not to fit the paradigm of theories which have been developed to account for other kinds of reinforcers.

Butler interprets his results to indicate the existence of a visual exploration drive that is similar to the primary drives in its strength and persistence. He has supported this contention by showing that opportunities for visual exploration can serve to reinforce the acquisition of a color discrimination (1953), that relative visual deprivation leads to its increased elicitation (1957), and that the visual exploratory responses are highly resistant to extinction. In another experiment, however, Butler (1955) has shown that the incentive conditions for which the animal works, in part, determine the rate of exploratory responses. A view of a moving train or another monkey, for example, is more effective in eliciting exploratory responses than is a view of either food, or an empty chamber. As thus far stated, Butler's visual exploration drive does not account for these differential effects.

The practice of hypothesizing a new drive state for every observed reinforcing effect is rather common in psychology, and is reminiscent

of psychology's compilation of instincts phase. Among the more credulous of the new drives are the novelty or curiosity drive (Berlyne, 1950), a manipulation drive (Harlow, Harlow and Meyer, 1950), a drive based on exploration (Welker, 1956; Montgomery, 1954), and a stimulus-change drive (Dember, 1957; Forgas and Levin, 1959). All these theories share the fault of limited generality. It is entirely conceivable that drive states and reinforcements can take on different observable forms, but drive states must certainly share a common attribute; if we assume that reinforcements change drive states in some way, it follows then that reinforcements, too, are alike in some way. Therefore, a theory of reinforcement which attempts to account for any demonstrated reinforcing operation must also account for all other reinforcing states of affairs with the same set of constructs.

From this argument, then, Butler's interpretation of his data can be criticized for its inadequacy as a drive-reinforcement concept. His interpretation may fit the obtained data, but it fails when forced to predict the results of experiments in other contexts, and even in similar situations, as it would in the case of a monkey given the opportunity to view a chamber containing a snake (Hebb, 1949, p. 242).

The drive reduction point of view, derived from Hull, is a good theory in that it is general, and with its secondary reinforcement postulates, it can be applied to these data. But Butler has argued that these reinforcing effects are primary and not secondary because of their demonstrated persistence, and further, because the toy train,

which presumably belongs to a class of stimuli completely alien to the monkey, nevertheless, elicited high response rates.

Neither a stimulus-change interpretation, with its roots in a contiguity principle, nor a novelty or curiosity hypothesis can be considered adequate to explain these data, not only because of a lack of generality of these hypotheses, but also because they would have failed to predict that Butler's monkeys (1954) were evidently more reinforced by a view of another monkey than by a completely novel stimulus, which was to the greatest degree different from the test chamber, the toy train. Since the exploration hypothesis is akin to these hypotheses, similar arguments can be made.

A manipulation hypothesis can likewise be discounted in the explanation of visual exploratory data in that it does not, like Butler's hypothesis, account for differential effects as a function of the incentive conditions. Opening a door to view an empty chamber provides just as much manipulation as the opening of the door to view another monkey.

Brown (1953) has expressed an anxiety-reduction explanation of these data; an explanation which is predicated on a secondary reinforcement principle. Butler has attempted to counter (1954), that the emotionality measures taken during his 1954 experiment were negatively correlated with successive test days, and that during the early sessions, the animals tended to remain at the rear of the box, which should have increased, rather than decrease the anxiety from being isolated in the box. The point could also be made that an anxiety-reduction

hypothesis would have predicted different preferences for incentive conditions than were displayed. For example, the view of the moving, clacking toy train probably induced more anxiety in the monkey than it reduced, but Butler found that this condition elicited very high response frequencies relative to the presumably anxiety-free condition of the empty chamber.

Since many of the above arguments offer no solution to the Butler data by virtue of the very complexity of his situation, it seems reasonable to attempt an analytical reduction of the Butler situation to its essential components and deduce from these what the important variables leading to reinforcement seem to be.

When a monkey looks through a window in Butler's experiments, at least three things happen. First, there is a change in the visual stimulation; second, the monkey sees the objects within view; and third, at least some of the objects have meanings derived through prior associations in other situations. Within this restricted framework, then, the problem reduces to one of three alternative hypotheses; that is, the basis of the reinforcing effect should be found in one of the three conditions described.

It seems unlikely that stimulus-change constitutes a reinforcement since it is unable to account for the fact that different kinds of change result in different effects. But, however, if the amount of change is invoked as being the important variable, a measurement problem emerges, and we are left with the question of how much change is entailed when relatively complex stimuli are considered. With this

added assumption, then, the first alternative hypothesis remains possible and testable, if the measurement problems can be surmounted.

That patterned stimulation does seem to make a difference was demonstrated by Butler by the increase in response rate engendered by the introduction of objects into the monkey's field of view. The Bexton, Heron, and Scott (1954) stimulus deprivation experiments also dramatically illustrate the importance of patterned stimulation. It seems that deprivation of patterned stimulation engenders a highly noxious state of drive, and that any pattern of stimulation is more reinforcing than no pattern at all. It is therefore important to determine whether a pattern of stimulation, in itself, divorced from all associated meaning, is reinforcing.

Finally, there remains the problem of whether the objects the monkey sees are reinforcing due to prior associations with other situations. As long as the visual situations used in experiments on this topic remain complex, however, the question will probably remain unanswered, regardless of how unlikely the possibility may seem. Thus in order to test this alternative hypothesis, it is necessary to use visual stimuli which are similar to Butler's in that they are patterned, but which are free of the possibility of associated meaning.

This experiment is a beginning in the quest for the resolution of these alternative hypotheses. Two of the variables have been controlled and the third was experimentally manipulated to assess its role as a reinforcer in the visual exploration experiments. To control for secondary reinforcing properties, a unique geometric visual form to

the monkey, a checkerboard, was chosen as the stimulus format. By systematic variation in the amount of structure in the patterns, a continuum was generated which extended from total randomness (no discernable pattern) at one end to maximal constraint (a perfectly defined pattern) at the other. By psychophysically scaling these patterns, an attempt was made to adjust the phenomenal distance between adjacent patterns to equality, in the hope that this operation would hold the amount of change between successive patterns constant, within certain limits.

Thus in using a series of nonsense (for the monkey) patterns (with presumably no derived reinforcing properties) which differed by the same amount, these two variables were controlled. By then arranging these patterns on a continuum from no pattern to a perfectly constrained one, a test of a stimulus constraint hypothesis was conducted. If patterning in the stimulus is sufficient to reinforce responses which lead to it, the monkey, when given control over which pattern he sees, will prefer to view constrained patterns over more random ones.

METHOD

Subjects

Seven male and five female monkeys (Macaca mulatta) all from the colony of the Laboratory of Comparative and Physiological Psychology, served as Ss. Their weights ranged from 4 to 7 pounds. Prior to this experiment, they had been tamed, used in a pattern discrimination study (Schuck, 1959), and in several further discrimination studies in

an automated discrimination apparatus (McConnell et al, 1959). Concurrently, they served as subjects in an automated replica of the Schuck pattern discrimination experiment.

Apparatus

The apparatus consisted of a chamber, an automatic slide projection system, and a recording network. The chamber's front and rear walls, ceiling and floor were made of $\frac{1}{4}$ inch black acrylic plastic sheeting. The sides were vision-proof ventilating panels, and the entire rear wall slid up as a door. Inside dimensions of the chamber were $21\frac{1}{2}$ in. deep by $21\frac{1}{2}$ in. high by 17 in. wide.

The front wall contained a four-inch square Polacoat lenscreen, whose center was 14 inches from the floor and centered between the walls. Two T-shaped handles of $\frac{1}{2}$ inch clear acrylic rod were positioned below the screen, with the crossbar of the T parallel to the front wall and the stem passing through the front to a spring-loading mechanism and a microswitch. To activate the microswitch, the handle had to be pulled $1/8$ inch from the front wall against a spring tension of a few grams. The centers of the cross-bars of the handles were 9 inches from the floor, and $4\frac{1}{2}$ inches from either side wall. The cross bars were 2 inches long, and their front surfaces were $3/4$ inch from the front wall. The stimulus patterns projected on the screen were the lone illuminative source in the chamber.

The projection system consisted of a Sarkes-Tarzian TSP-6A automatic slide projector with a circular slide magazine and a bidirec-

tional sequence control unit. This system permits the sequential presentation of 50 2"x2" slides in either direction. Generating pulse "A" (by S pulling one handle) automatically lowers a shutter, returns slide N to the circular drum, rotates the drum one position forward, positions slide N+1 for projection, and raises the shutter to rear-project the slide on S's screen. This operation takes place in 0.6 second. Generating pulse "B" (S pulling the other handle) results in the same sequence of events, except that the drum rotation is reversed, and slide N-1 is projected. The operation of the shutter obviates the movement of the slides so that during slide changing, S's screen is dark.

The recording network consisted of a bank of 15 relays and an Esterline-Angus 20-channel operations recorder. One of the five decade relays was energized when the slide drum was positioned in each of the five decades (00 through 09, 10 through 19, ... 40 through 49) of the 50 position drum. One of the ten digital relays was energized when the slide drum was in each of the ten digital (0 through 9) positions. Thus for each slide position, a unique pair of decade and digital relays were energized and by passing the recorder pen circuits in series through the normally open contacts of both relays, the occurrence of that slide was recorded. The duration of exposure was indicated by the length of line made on the recording chart moving at a known speed. Since only 14 different slides were used in this experiment, the recording pen circuits to all drum positions containing the same slide were connected in parallel, thus recording presentation of a given slide regardless of its location in the slide drum.

Stimuli

The stimuli used in this experiment were patterns of white dots on a black background. These stimuli were generated at the computer facilities at the Lincoln Laboratories of MIT by Drs. Bert F. Green, Jr., and Benjamin White, and representative samples of this general class of stimuli appear in Green, 1957. In every case, 4608 dots were arranged within a matrix of 500 x 500 possible dot positions. The arrangement, or configuration of the dots was manipulated to produce a constrained-random continuum. The first pattern of the series, the one maximally constrained, was a four by four checkerboard of alternate black and white squares. The second pattern was produced by moving each one of the dots on a random walk of 20 dot positions from its original, maximally constrained position to its pattern number two position. The effect of this operation was to make the pattern less distinct, in that the formerly white squares now had black holes in them, and in that the borders of the squares had several dots around the periphery. The same random-walk operation was performed on pattern two to produce pattern number three. This pattern, then, was even less distinct than number two. The same operation was performed again and again to produce 50 patterns. In pattern number 50, the dot distribution was at least phenomenally random; nowhere in the matrix was there any trace of the basic figure.

One unique feature of these stimuli are that each pattern contains the same number of dots of the same size. The total light energy from each pattern is therefore the same. Further, each dot is perfectly in

focus on every pattern; only the configuration of the dots changes from pattern to pattern.

Inspection of the continuum thus obtained showed that the patterns in the constrained end of the series were clearly discriminable from adjacent ones, but toward the middle of the series, and especially toward the random end, adjacent patterns were not discriminably different. In order to perceive differences, it was necessary to compare patterns several steps apart. Since the experiment required that the patterns to be used would comprise a continuum whose adjacent patterns would be discriminably different, and equally spaced, a preliminary experiment was performed to construct such a continuum.

Since the number of monkeys available was limited to twelve, and since using the monkeys to scale these stimuli would have necessitated the use of primary rewards, which would have introduced a contaminating variable into the main experiment (the opportunity for secondary reinforcing properties to be established), it was decided to use human Ss to scale the stimuli. The Ss, 96 in all, were shown pairs of patterns and asked to judge whether the second of the pair was more constrained than the first, or more random. Each pair of patterns tested were shown in both ascending and descending sequences. Table 1 of the Appendix shows the results of this psychophysical experiment. Down the side of this table are listed one pattern of a pair (N), and A for ascending comparison, D for descending, and across the top are listed the patterns with which pattern N was compared ($N/1, N/2 \dots$). In the body of the table appear the percentage of correct judgments, and a

superscript indicating the number of judgments upon which that percentage was based. An arbitrary criterion of discriminability was chosen as 75% correct judgments. Accordingly, patterns 1, 2, 3, 4, 5, 7, 9, 11, 14, 18, 24, 32, 41, and 50 were chosen as the continuum to be used in this experiment. Hereafter they will be referred to as patterns 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14.

It should be noted, however, that the data in Table 1 indicate larger differences between the patterns at the constrained end of the chosen series, than at the random end. Since the choice of stimuli was restricted to these given patterns, they had to be used even though larger differences were observed at this end of the continuum. The effect of this inadequacy of scaling should bias the results of the experiment toward the constrained end if a greater amount of change constitutes a reinforcing state of affairs.

The patterns were arranged in the circular drum as follows: pattern 1 was put in drum position 00, pattern 2 in position 01, pattern 3 in position 02 ... and pattern 14 in position 13. The series was then folded back upon itself so that pattern 13 was put in position 14, pattern 12 in 15, 11 in 16, 10 in 17 ... and pattern 1 in position 26. The series was once again folded on itself with the exception that pattern 13 had to be omitted in this half of the drum in order to accommodate the series in the 50 position drum. Pattern 2, therefore, was put in position 27, 3 in 28, ... 12 in 37, 14 in 38, (and folding the series once again) 12 in 39, 11 in 40, ... 2 in 49, and of course 1 in position 00 as indicated in the beginning. The drum was

thus divided into approximate fourths; in each fourth was a constrained to random series, and the ends of each series was turned so that like ends were adjacent.

When the monkey started on pattern 14 and consistently pulled one handle, he showed himself patterns increasing in constraint until he presented pattern 1. He then presented increments in randomness until pattern 14 was reached, and then increments in stimulus constraint to pattern 1, and so on. Only by changing handles was the S able to maintain any one pattern or group of patterns, since a response to the opposite handle reversed the slide projector and showed the pattern he had just passed. It should be noted that this arrangement automatically controlled for S's position preference and made all aspects of the experiment completely under the control of S. He had control over which pattern was on the screen, how long it remained on the screen, and indeed, whether or not he responded at all.

Procedure

No pretraining was used in this experiment. S was simply put into the chamber and his tendency to pull things was employed as an operant. Due to the lack of experiments of this general type, many procedural details had to be determined by experimentation. Three animals, numbers 3, 5, and 10, were therefore chosen as Ss for a pilot experiment to determine the procedures to be used in the experiment proper.

Initially it was planned that an animal would be run for an eight-hour session if he made no responses in that time; or if he did respond,

his session would be terminated in four hours, and every succeeding session would be of four hours. Of the three animals tested, none required the eight-hour session, the initial eight-hour session was therefore abandoned, and all Ss were tested once a day for nine successive days. At this time their performance appeared asymptotic with respect to their operant rate.

Since the Ss in this experiment were tested only after they had been tested in the automated discrimination experiment, and had been fed, and since twelve hours was required to test all three Ss, the daily experimental sessions ran until 11:00 or 12:00 p.m. It was noted that after sundown (about 8:00 p.m.), Ss maintained their diurnal rhythm and went to sleep.

For the final nine Ss in the experiment proper, therefore, three Ss were run per day, one three-hour session per S per day (since it was learned that operant rates consistently decreased during the fourth hour), and nine successive days of testing. Testing began between 8:00 and 9:00 a.m. and was completed by 5:00 or 6:00 p.m. Harlow (1950) has also found that a three-hour session of manipulation experimentation avoids a considerable fall in operant rate after the third hour.

Every session for every animal was begun with the slide projector on pattern 14. This was done for three reasons: first, every S received the same treatment; second, it systematically biased the experiment against the experimental hypothesis rather than having it biased in favor of the hypothesis; and third, regardless of which response the S made first, he always received an increment in the constraint of the pattern.

Sequential order of testing was randomized with the restriction that each S was tested in every order of the day an equal number of times.

A session was begun by indexing pattern 14 on the screen and transferring S from a transport cage into the test chamber through the vertically-sliding rear wall which served as a door. A white noise of 88 db SPL (as measured in the test chamber) was used to mask distracting noises in the laboratory. This noise level has been used in all experiments in which these monkeys have participated.

RESULTS

Two Ss, number 8 and number 11, made no responses throughout the nine three-hour sessions. Two Ss, number 2 and number 9, made a few responses during the first session, but no responses on the subsequent nine sessions. Since at least some response rate is needed to test any hypothesis, these Ss were discarded from the experiment, and the results are therefore reported on the basis of eight Ss. Five of these eight Ss started responding from the first session, the remaining three, numbers 1, 6, and 7, began responding in the second, fourth and fourth sessions, respectively. All Ss continued to respond consistently throughout the nine sessions with the following exceptions: S 4's second session was lost because of an apparatus failure; S 3 failed to make responses during sessions four, six and eight; and S 10 failed to respond on the second, sixth, and seventh sessions. Both S 3 and S 10

were in the pilot study in which Ss were run for four hours, and run late in the evening. In every case, the sessions within which no responses were made were the last session of the day, a session which usually started about 8:00 p.m. and lasted until midnight. It was assumed that the Ss were sleeping during this time, since during daylight hours, these Ss responded well.

The results of each animal's performance on each of the nine sessions is presented in Figures 1 through 46. In all cases, session number is indicated by a Roman numeral and animal number by an Arabic numeral. The data are plotted as histograms with pattern 1 through 14 on the abscissa, and the proportion of responses made to present that pattern on the ordinate. The second histogram for a given animal and a given session is a plot of the proportion of time each pattern was projected on the screen. In addition to the session by session data, the results of an animal's performance on the first three, second three, and third three sessions, together with a plot of all nine sessions combined, is shown in the last two figures of each S's section. Appearing in the body of the histograms depicting proportion of responses are three additional data: the chi-square value of the distribution presented, in parentheses appears the significance level of that value with 13 degrees of freedom (where n.s. indicates that the value does not exceed the 5% level of confidence), and finally N, the number of responses made during that session or group of sessions. Where a chi-square value is not reported, one or more of the expected cell frequencies were less than five, making the statistic inappropriate.

No statistical analysis was performed on the time data, since the variability between adjacent patterns is so large that an interpretation of trend is impossible. This large variability was due principally to long durations which seemed to occur at random. It seems likely that during these long intervals the animals withdrew from the experimental situation and indulged in irrelevant behaviors, as evidenced by the amount to which the test chamber had been scratched and chewed.

Table 2 indicates the number of sessions and groups of sessions which had distributions statistically significantly different from chance (level of confidence exceeding 5%) and the trends of these distributions as determined by visual inspection. A trend toward constraint would be indicated by a disproportionately large number of responses in the constrained (toward pattern 1) end of the series. Inspection of this table shows that no category of trend is predominant.

CONCLUSIONS

Since the experimental hypothesis was that the animals would show themselves more constrained patterns than random ones, we conclude that this hypothesis was not supported by these data. And since the amount of stimulus-change could not be adequately controlled at the constrained end of the continuum, and no trend toward this end was obtained, we conclude that the stimulus-change hypothesis is likewise not supported by these data.

If it is assumed that the monkeys learned the response contingencies involved, we can conclude, then, that by exclusion, these data give tentative support to the hypothesis that visual reinforcements are derived.

EXPERIMENT II

INTRODUCTION

The results of experiment I left the stimulus constraint hypothesis open to question since the data can be explained by three hypotheses:

1. Stimulus constraint, in itself, cannot serve as a reinforcer;
2. Visual stimuli acquire their reinforcing properties only through association with other reinforcers; or 3. The response contingencies that had to be learned in this experiment in order for the animal to show himself any group of patterns were too difficult to be learned in the nine three-hour sessions. It was therefore decided to perform an additional experiment in an attempt to eliminate one or more of these hypotheses.

Since it was felt that experiment I was an adequate test for the first two hypotheses, the third hypothesis was brought under more critical examination to evaluate its validity. It was therefore decided that experiment II would be essentially the same as experiment I, except that the response contingencies would be changed so as to facilitate the learning of these contingencies. Specifically, the apparatus was modified so that within a given session, responses to one side would invariably drive the projector toward one end of the series, while responses to the other side would drive the projector toward the other end. In this way, a particular response within a given session would

consistently lead to increments in the constraint of the stimulus, and if this is a reinforcing operation, the probability of that response should increase. Since the handle which will lead to increments in constraint would be counterbalanced to control for position preferences, the monkey should develop a learning set that one of the handles will always lead to increments in constraint within a given session.

METHOD

Subjects

Only the eight Ss (numbers 1, 3, 4, 5, 6, 7, 10, and 12) who displayed sufficiently high operant rates in experiment I were used in this experiment. It will be remembered that only the data of these eight Ss were reported in experiment I since two of the four discarded Ss made no responses, and the remaining two Ss made only a few responses on the first session, and none subsequently.

Apparatus

The same apparatus was used in this experiment as was used in experiment I with the following exceptions: 1. Only ten positions of the circular slide drum were used, and one random-to-constrained series of ten patterns was placed in these ten positions in sequential order. 2. In any one session, a response to the left handle, for example, consistently led to increments in the constraint of the pattern until the maximally constrained pattern was projected. At that time, continued left responses resulted in no change of the stimulus, but these

additional responses were recorded. During the same session, of course, right responses led consistently to increments in the randomness of the pattern until maximal randomness was projected. Additional right responses led to no change in the stimulus, and these responses were recorded. Provision was also made for interchanging these relationships, that is, whether right handle responses led to increments in constraint or randomness was under the control of E.

The occurrence of each of the ten patterns was recorded on the operations recorder as in experiment I.

Stimuli

Ten of the fourteen patterns used in experiment I were used in this experiment. They were original patterns 1, 2, 3, 4, 5, 7, 9, 11, 14, and 50, which corresponds to patterns 1, 2, 3, 4, 5, 6, 7, 8, 9, and 14 as used in experiment I. It will be noted that the same series was used with the omission of patterns 10 through 13. The effect of this is to produce a larger difference between patterns 9 and 14 (the last two in the series) than between any other patterns except 1 and 2, thus making the series somewhat symmetrical with respect to amount of change between adjacent patterns.

Procedure

The eight Ss were tested for ten two-hour sessions, one session per day. Four Ss were tested each day, and any given S was tested on alternate days. The initial assignment as to whether an animal was to

be tested on the first or second day (and subsequently on even-numbered or odd-numbered days) was made randomly. Each S began each of the ten sessions on a different one of the ten possible patterns each session, with the order of presentation being random. The handle which would lead to increments in constraint was counterbalanced so that in successive pairs of sessions each condition occurred once, the order being random. Thus the same condition never occurred more than twice in succession, and the conditions occurred equally often.

The order of testing of the four Ss in one day was balanced so that each S was tested first, second, third and fourth two times each, and the order of the remaining two sessions was determined randomly. Testing started between 8:00 and 9:30 a.m. and was completed between 4:00 and 5:30 p.m. As in experiment I, Ss were tested only after they had been tested in the automated apparatus and fed their daily ration.

RESULTS

Since the operant rate of animal number 1 fell to a very low rate throughout the 10 sessions, his data are not included in the following analysis.

As expected, position preferences were observed in almost all animals. Since successive pairs of sessions were counterbalanced with respect to laterality, however, the data of these pairs can be pooled and presented as a datum free from position preferences. The results of experiment II, thus pooled, are presented in Figures 47, 48, and 49. On the axis of abscissae are successive pairs of sessions, and all

sessions (1 through 10) combined, and on the axis of ordinates of one histogram for a given animal are the proportion of responses made to produce patterns 1 through 5 (the constrained half of the series). On the axis of ordinates of the other histogram is the proportion of time that patterns 1 through 5 remained on the screen. Each animal's data are presented for each pair of sessions and for all 10 sessions combined, and in the last two histograms are the pooled data from all seven subjects.

Above or below each bar in each histogram is given the significance level for the data, or ns indicating that the significance level was below .05. These significance levels were determined by computing the chi-square value of the distributions of responses (and time) within the classes 1 through 5, and 6 through 10, and hence $df = 1$. Since responses to produce patterns 1 and 10 can be made repeatedly, the expected frequencies of these patterns are indeterminate. But since their expected frequencies are equal, regardless of their absolute value, and since the expected frequencies of patterns 2 through 5, and 6 through 9 are also equal, the two halves of the series are equally probable, and the departure of these halves of the series from a probability of 0.50 can be tested with chi-square.

Inspection of these data shows that no systematic trends can be observed. This point is better illustrated by Table 3, which presents the number of pairs of sessions and groups of 10 sessions which were significantly different from chance, and the trends noted. It is

obvious that no trend predominates. Likewise, the results of all sessions for all Ss given in the lower half of Figure 49 shows no significant difference.

DISCUSSION

From the results of experiment I we tentatively concluded that visual stimuli gain their reinforcing properties through prior associations. This, of course, involves the assumption that the animals had learned the stimulus-response contingencies. From the results of experiment II, in which the contingencies were simplified, we concluded that since no systematic trend in pattern was noted, and since no cumulative learning effects were noted, one of four explanations fit the data from both experiments.

It may be that the stimulus-response contingencies used in these experiments were not learnable either because 1, the length of training was too short, or 2, the hypothetical reinforcements resulting from increments in the constraint of the stimulus pattern were not sufficiently strong to provide the basis for learning. But, however, if these situations were learnable, we are left with the remaining two alternatives: that increments in stimulus constraint are not reinforcing events, or that visual reinforcements are derived.

On the basis of the data presented in this dissertation, it is not possible to decide which of these alternatives is correct. The most likely mode of attack for future research on this problem seems to be a further simplification of the problem in terms of the operations

required of the monkey. To this end, additional experiments will be conducted to determine if increments in stimulus constraint, intermittently presented, can engender changes in rate of responding, just as intermittent food reinforcements lead to characteristic changes in response rate. Thus the situation is simplified to a single manipulandum which produces changes in stimulus constraint. If these periodic increments in constraint produce characteristic changes in rate, the learning explanations can be discarded, the secondary reinforcement hypothesis can likewise be discarded, and a verification of a stimulus constraint hypothesis is possible.

SUMMARY AND CONCLUSIONS

These experiments were developed as a test of the hypothesis that visual stimuli are reinforcing to monkeys in that they provide increments of stimulus constraint. Rhesus monkeys were tested in a situation where they could present themselves with patterns which varied on a constrained-random continuum. The maximally constrained pattern consisted of a checkerboard of alternately black and white squares, and increments of randomness were introduced by manipulating the position of the white dots (which made up all the patterns) so that the patterns looked progressively less distinct toward the random end of the series. The pattern projected on the monkey's screen, the duration it stayed on the screen, and the rate at which responses were made were under the control of the monkey.

An analysis of the data revealed no systematic effects. No pattern or group of patterns were preferred over any other. Therefore, within the conditions of these experiments, the experimental hypothesis was not supported. The data do, however, give indirect support to the view that visual stimuli gain their reinforcing properties through prior associations.

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APPENDIX

EXPERIMENT I

Figures 1 through 6

Response and Time Data for S Number 1 by Sessions,
Groups of Three Sessions, and all
Nine Sessions Combined

PROPORTION OF RESPONSES

PROPORTION OF TIME

EXPERIMENT I

Figures 7 through 11

Response and Time Data for S Number 3 by Sessions,
Groups of Three Sessions, and all
Nine Sessions Combined

EXPERIMENT I

Figures 12 through 17

Response and Time Data for S Number 4 by Sessions,
Groups of Three Sessions, and all
Nine Sessions Combined

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

EXPERIMENT I

Figures 18 through 24

Response and Time Data for S Number 5 by Sessions,
Groups of Three Sessions, and all
Nine Sessions Combined

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

SESSION IX

EXPERIMENT I

Figures 25 through 29

Response and Time Data for S Number 6 by Sessions,
Groups of Three Sessions, and all
Nine Sessions Combined

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

EXPERIMENT I

Figures 30 through 34

Response and Time Data for S Number 7 by Sessions,
Groups of Three Sessions, and all
Nine Sessions Combined

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

EXPERIMENT I

Figures 35 through 39

Response and Time Data for S Number 10 by Sessions,
Groups of Three Sessions, and all
Nine Sessions Combined

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

EXPERIMENT I

Figures 40 through 46

Response and Time Data for S Number 12 by Sessions,
Groups of Three Sessions, and all
Nine Sessions Combined

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

PROPORTION OF RESPONSES

PROPORTION OF TIME

EXPERIMENT II

Figures 47 through 49

Proportion of Responses and Proportion of Time for
Patterns 1 through 5 for all seven Ss, and
for all Ss Combined

PROPORTION OF RESPONSES TO PATTERNS 1 THROUGH 5

S 5

S 4

S 3

PROPORTION OF TIME IN PATTERNS 1 THROUGH 5

SESSIONS

* .001
X .01
.05
- n.s.

PROPORTION OF RESPONSES TO PATTERNS 1 THROUGH 5

PROPORTION OF TIME IN PATTERNS 1 THROUGH 5

PROPORTION OF RESPONSES TO PATTERNS 1 through 5

PROPORTION OF TIME IN PATTERNS 1 THROUGH 5

Table 1

Percentage Correct Judgments between Patterns N & N / x
 (Superscript refers to number of judgments)

Pattern N	N/1	N/2	N/3	N/4	N/5	N/6	N/7
1 A	95.0 ^x	85.7 ⁻	92.8 ⁻				
D	100.0 ⁻	100.0 ⁻	100.0 ⁻				
2 A	90.6 [•]	85.7 ⁻	95.0 ^x				
D	90.6 ^x	100.0 ^x	100.0 ⁻				
3 A	93.3 ^x	93.3 ^x	92.8 ⁻				
D	76.7 ^x	89.3 ⁻	96.4 ⁻				
4 A	75.0 ⁻	82.1 ⁻	92.8 ⁻				
D	96.4 ⁻	96.4 ⁻	95.0 ^x				
5 A	69.8 [•]	85.7 ⁻	96.7 ^x				
D	68.3 ^x	89.3 ⁻	85.0 ^x				
6 A	67.8 ⁻	94.8 [•]	92.8 ⁻				
D	85.7 ⁻	88.3 ^x	81.7 ^x				
7 A	88.3 ^x	92.8 ⁻	96.4 ⁻				
D	68.3 ^x	85.7 ⁻	80.0 ^x				
8 A	75.0 [•]	65.0 ^x	71.7 ^x				
D	28.3 ^x	31.7 ^x	41.7 ^x				
9 A	67.8 ⁻	85.7 ⁻	85.7 ⁻				
D	42.8 ⁻	60.7 ⁻	75.0 ⁻				
10 A	92.8 ⁻	75.0 ⁻	82.1 ⁻				
D	75.0 ⁻	67.8 ⁻	85.7 ⁻				
11 A	53.6 ⁻	50.0 ⁻	78.6 ⁻				
D	21.4 ⁻	35.7 ⁻	78.6 ⁻				

Table 1 - continued

Pattern	N	N/1	N/2	N/3	N/4	N/5	N/6	N/7
12	A	64.2 ⁻	82.1 ⁻	78.6 ⁻				
	D	25.0 ⁻	53.6 ⁻	53.6 ⁻				
13	A	50.0 ⁻	57.1 ⁻	75.0 ⁻				
	D	50.0 ⁻	46.4 ⁻	42.8 ⁻				
14	A	75.0 ⁻	75.0 ⁻	75.0 ⁻	87.5	75.0	78.1 ⁰	
	D	35.7 ⁻	46.4 ⁻	60.7 ⁻	34.4	31.2	34.4	
15	A	60.0 ^x	85.7 ⁻	60.7 ⁻	78.1	81.2	53.1	
	D	64.2 ⁻	53.6 ⁻	56.7 ^x	56.2	37.5	71.9	
16	A	64.2 ⁻	46.7 ^x	71.4 ⁻	56.2	62.5	50.0	
	D	53.6 ⁻	57.1 ⁻	53.6 ⁻	31.2	40.6	59.4	
17	A	46.4 ⁻	58.3 ^x	50.0 ⁻	71.9	53.1	78.1	
	D	39.3 ⁻	42.8 ⁻	42.8 ⁻	59.4	50.0	62.5	
18	A	67.8 ⁻	39.3 ⁻	50.0 ⁻	59.4	65.6	78.1	
	D	35.7 ⁻	60.7 ⁻	60.7 ⁻	56.2	56.2	75.0	
19	A	53.6 ⁻	64.2 ⁻	60.7 ⁻	71.9	75.0	78.1	62.5
	D	60.7 ⁻	50.0 ⁻	60.7 ⁻	65.6	71.9	71.9	
20	A	57.1 ⁻	60.7 ⁻	78.6 ⁻	70.3 ⁰	59.4	53.1	
	D	53.6 ⁻	50.0 ⁻	46.4 ⁻	65.6	68.7	53.1	
21	A	57.1 ⁻	82.1 ⁻	82.1 ⁻	65.6	75.0	75.0	
	D	60.7 ⁻	67.8 ⁻	82.1 ⁻	56.2	68.7	53.1	
22	A	39.3 ⁻	75.0 ⁻	60.7 ⁻	65.6	68.7	71.9	
	D	46.4 ⁻	82.1 ⁻	71.4 ⁻	65.6	31.2	71.9	

Table 1 - continued

Pattern	<u>N</u>	N/1	N/2	N/3	N/4	N/5	N/6	N/7
23	A	60.7 ⁻	71.4 ⁻	71.4 ⁻	68.7	46.8	59.4	
	D	51.7 ^x	67.8 ⁻	65.0 ^x	75.0	75.0	71.9	
24	A	60.7 ⁻	46.4 ⁻	53.6 ⁻	59.4	75.0	71.9	
	D	50.0 ⁻	46.4 ⁻	67.8 ⁻	76.6 ^o	-	31.2	
25	A	60.7 ⁻	60.0 ^x	60.7 ⁻	50.0	65.6	62.5	
	D	61.7 ^x	43.3 ^x	25.0 ⁻	34.4	50.0	62.5	
26	A	67.8 ⁻	60.7 ⁻	46.4 ⁻	75.0	71.9	71.9	
	D	50.0 ⁻	57.1 ⁻	60.0 ^x	68.7	71.9	78.1	
27	A	67.8 ⁻	28.6 ⁻	43.3 ^x	56.2	68.7	87.5	
	D	46.4 ⁻	39.3 ⁻	32.1 ⁻	65.6	65.6	65.6	
28	A	39.3 ⁻	53.6 ⁻	61.7 ^x	68.7	75.0	87.5	
	D	35.7 ⁻	39.3 ⁻	57.1 ⁻	50.0	62.5	62.5	
29	A	60.7 ⁻	64.2 ⁻	60.7 ⁻	65.6	71.9	75.0	
	D	53.6 ⁻	53.6 ⁻	64.2 ⁻	78.1	75.0	68.7	
30	A	60.0 ^x	60.7 ⁻	60.7 ⁻	68.7	56.2	50.0	62.5
	D	53.6 ⁻	57.1 ⁻	71.4 ⁻	46.8	53.1	53.1	46.8
31	A	53.6 ⁻	64.2 ⁻	75.0 ⁻	64.1 ^o	65.6	68.7	70.3 ^o
	D	46.4 ⁻	35.7 ⁻	53.6 ⁻	59.4	68.7	71.9	68.7
32	A	64.2 ⁻	67.8 ⁻	78.6 ⁻	75.0	56.2	65.6	81.2
	D	46.4 ⁻	50.0 ⁻	60.7 ⁻	43.8	43.8	40.6	56.2
33	A	64.2 ⁻	64.2 ⁻	67.8 ⁻	50.0	-	-	50.0
	D	50.0 ⁻	35.7 ⁻	42.8 ⁻	40.6	37.5	-	-

Table 1 - continued

Pattern	N	N/1	N/2	N/3	N/4	N/5	N/6	N/7
34	A	57.1 ⁻	46.4 ⁻	48.3 ^x	68.7	65.6	59.4	68.7
	D	28.6 ⁻	28.6 ⁻	50.0 ⁻	25.0	37.5	37.5	56.2
35	A	39.3 ⁻	53.6 ⁻	39.3 ⁻	71.9	56.2	78.1	75.0
	D	42.8 ⁻	53.6 ⁻	53.6 ⁻	50.0	53.1	28.1	53.1
36	A	67.8 ⁻	71.4 ⁻	64.2 ⁻	53.1	71.9	75.0	75.0
	D	57.1 ⁻	53.6 ⁻	67.8 ⁻	46.8	34.4	59.4	53.1
37	A	68.4 ^o	50.0 ⁻	43.3 ^x	59.4	84.4	65.6	56.2
	D	31.6 ^o	32.1 ⁻	39.3 ⁻	59.4	62.5	40.6	37.5
38	A	32.1 ⁻	39.3 ⁻	75.0 ⁻	40.6	81.2	46.8	40.6
	D	53.6 ⁻	42.8 ⁻	46.4 ⁻	56.2	56.2	53.1	31.2
39	A	71.4 ⁻	60.7 ⁻	57.1 ⁻	56.2	51.6 ^o	37.5	62.5
	D	35.7 ⁻	57.1 ⁻	50.0 ⁻	35.9 ^o	37.5	43.8	50.0
40	A	75.0 ⁻	53.6 ⁻	55.0 ^x	40.6	46.8	59.4	57.8 ^o
	D	39.3 ⁻	46.4 ⁻	50.0 ⁻	28.1	40.6	59.4	50.0
41	A	46.4 ⁻	53.6 ⁻	64.2 ⁻	43.8	68.7	50.0	71.9
	D	42.8 ⁻	32.1 ⁻	39.3 ⁻	43.8	46.8	34.4	43.8
42	A	64.2 ⁻	82.1 ⁻	50.0 ⁻	43.8	53.1	50.0	62.5
	D	42.8 ⁻	42.8 ⁻	57.9 ^o	31.2	28.1	31.2	40.6
43	A	36.8 ^o	46.4 ⁻	36.8 ^o	59.4	60.9 ^o	65.6	78.1
	D	53.6 ⁻	4.74 ^o	53.1	56.2	46.8	31.2	68.7
44	A	42.1 ^o	63.2 ^o	42.1 ^o	68.7	87.5	81.2	
	D	42.8 ⁻	31.6 ^o	42.1 ^o	46.8	62.5	71.9	

Table 1 - concluded

Pattern	<u>N</u>	N/1	N/2	N/3	N/4	N/5	N/6	N/7
45	A	62.5	43.8	31.6 ^o	78.1	78.1		
	D	57.9 ^o	53.1	59.4	65.6	65.6		
46	A	26.3 ^o	52.6 ^o	63.2 ^o	78.1			
	D	63.2 ^o	42.1 ^o	57.9 ^o	60.9			
47	A	57.9 ^o	57.9 ^o	75.0 ⁻				
	D	40.6	84.2 ^o	63.2 ^o				
48	A	57.9 ^o	42.1					
	D	37.5 ^o	57.9 ^o					
49	A	68.4 ⁻						
	D	-						

No superscript indicates 32 judgments

- indicates 28 judgments

o indicates 64 judgments

x indicates 60 judgments

. indicates 96 judgments

o indicates 19 judgments

Table 2

Number of Sessions and Blocks of Sessions Statistically
Significantly Different from Chance,
and the Trend Noted in Each Case

	Trend				
	Total	Constrained	Random	Middle	No Trend
Significant Sessions	31	10	11	3	7
Significant blocks of three Sessions	9	2	4	2	1
Significant blocks of nine Sessions	3	1	1	0	1

Table 3

Number of Pairs of Sessions and Blocks of 10 Sessions (1 S's data)
 whose Distributions were Significantly Different from Chance,
 and the Trend noted in each Case

	Total	Trend	
		Constrained	Random
Significant pairs of sessions	23	10	13
Significant blocks of 10 sessions	16	7	9

AUTOBIOGRAPHY

I, Vincent James Polidora, was born in Leetsdale, Pennsylvania, June 15, 1931. I received my secondary school education at the Ambridge, Pennsylvania, high school, and my undergraduate training at the Ohio State University, which granted me the Bachelor of Arts degree in 1954. I was granted the Master of Arts degree from the same university in 1955. During this, my first graduate year, I was Research Assistant in the Laboratory of Aviation Psychology. I subsequently served two years in the U. S. Army, being stationed at the U. S. Army Medical Research Laboratory at Fort Knox, Kentucky. In 1957 I returned to the Ohio State University as a University Fellow. I held this position for one year, and for the final year of predoctoral study to complete the requirements for the degree Doctor of Philosophy, I was appointed U. S. Public Health Service Predoctoral Fellow. During these two years I participated in the research being conducted at the Laboratory of Comparative and Physiological Psychology.