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Stimulus sequence effects in a discrete trial discrimination
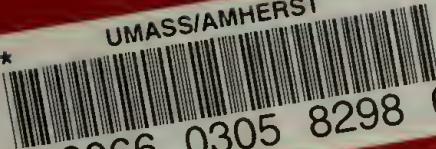
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STIMULUS SEQUENCE EFFECTS IN A DISCRETE TRIAL

DISCRIMINATION

A Thesis Presented

By

James Vance Couch

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DISCRIMINATION

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Finally I wish to acknowledge my wife, Linda. Her help and support during these years has been invaluable.

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C H A P T E R I
INTRODUCTION

That a subject responds at a particular rate in the presence of one stimulus and at a different rate in the presence of other stimuli on the same dimension has been taken as indicative of the acquisition of dimensional stimulus control over the subject's behavior. Theories accounting for discrimination-derived phenomena in animals have been advanced by Pavlov (1927) and by Spence (1937). The Spencian model assumes that if a response is followed by a reinforcement, "the excitatory tendencies of the immediate stimulus components are reinforced or strengthened..." (Spence, 1936, p. 273). Furthermore, if an instrumental response leads to nonreinforcement, then the tendency to respond to the stimulus components present on that trial are weakened. These two assumptions set the conditions for the gradual strengthening of a response in the presence of the reinforced stimulus (the positive stimulus or S+) and the gradual weakening of the tendency to respond in the presence of the negative stimulus (S-). Since the tendency to respond to the positive stimulus generalizes to surrounding stimuli, a gradient of acquisition effects is assumed to develop along the S+ stimulus dimension with the mode occurring at the S+. Likewise, a gradient of

extinction effects, centered at the S-, is assumed to develop on the S- stimulus dimension. If the S+ and the S- coexist on the same stimulus dimension, then the gradients of acquisition and extinction effects may interact giving rise to what has been termed the post-discrimination gradient.

The characteristics of the empirical PDG (Hanson, 1959) are (1) a displacement of the mode away from the S- (peak shift), (2) a steepening of the gradient in the region of S- as compared with the S+ region, and (3) an elevation in response rate above that of a gradient obtained following single stimulus training to S+ alone. The first two empirical characteristics are easily derivable from Spence's model by simple algebraic summation of the acquisition and extinction tendencies while the third characteristic is not predicted by Spence's model. Instead of the elevated response rate characteristic of the PDG, Spence predicts that the PDG will be entirely contained within the single stimulus gradient. Gynther (1957) obtained a PDG which was contained within the single stimulus gradient using the classical conditioning paradigm.

Test of Spence's model. It should be noted that according to the Spencian analysis the necessary and sufficient conditions for the PDG are the formation of a gradient of acquisition effects around the S+ and a gradient of extinction effects around S-. No specific

training conditions are delineated except that reinforcement be scheduled in the presence of S+ and nonreinforcement in the presence of S-. Therefore in a situation in which massed acquisition is given to S+ followed by massed extinction to S-, it would be predicted that a PDG, typical of that obtained when S+ and S- are randomly presented, would be obtained. Honig, Thomas, and Guttman (1959) performed the above experiment and reported results counter to Spence's model. Briefly, pigeons were exposed to a variable interval one minute (VI 1) schedule of reinforcement in the presence of a 550 nm stimulus light for 10 days followed by either 20 or 40 minutes of massed extinction in the presence of a 570 nm stimulus light. On the following day, a stimulus generalization test along the wavelength dimension was conducted. When the PDG for the above group was compared with that for a similar control group which received no massed extinction, there were no reliable differences in the shapes of the gradients. That is, the group which received massed acquisition and massed extinction exhibited no peak shift, no steepening of the gradient in the S- region, and no gradient elevation. A typical PDG was obtained from these birds, however, following training using the random presentations of the S+ and the S-.

According to Spence's formulation, the Honig, et al (1959) procedure should have produced a gradient of acqui-

sition effects around the 550 nm stimulus and a gradient
of extinction effects centered around 570 nm. Therefore
since the two stimuli lie on the same dimension, the
gradients would interact thereby generating a PDG. By
failing to obtain a PDG at least two possible reasons may
be advanced. First, an absence of excitatory control
could have resulted in the failure to produce the PDG.
This argument is countered, however, by the similarity in
gradient shape between the group given single stimulus
training and the massed acquisition-extinction group.
Secondly, a lack of extinction effects around the S- could
account for the absence of the PDG. This reason is sup-
ported by the finding of Weisman and Palmer (1969) which
replicated Honig et al (1959) while using orthogonal stimulus
dimensions. Their results indicated that massed extinction
following VI 1 training produced no inhibitory gradient
around the S-.

Stimulus Sequence Effects

Another difference between the Honig et al (1959)
technique and the standard operant discrimination paradigm
(which produces a PDG) concerns the sequence of S+ and S-
trials. In the standard paradigm, four possible sequences
of stimuli are possible: S+S+, S+S-, S-S+, S-S-. However
in the Honig et al training procedure a subject receives
many S+S+ and S-S- transitions while receiving only one
S+S- and no S-S+ transitions. Yarczower and Switalski (1969)

exposed goldfish to a sequence of 20 S+ trials followed by
20 S- trials each day for a total of 25 daily sessions.
A second group of goldfish received randomly alternating
S+ and S- trials each day. When gradients of generalization
were obtained, it was observed that goldfish receiving
interspersed S+ and S- training exhibited sharpening of
stimulus control and marked diminution in response rate
in the region of S- (peak shift). However, the gradients
obtained from goldfish given daily S+ followed by S- training
indicated reduced stimulus control.

The Ellis investigation. A more direct test of the
importance of sequence effects was performed by Ellis (1970).
In this investigation, independent groups of pigeons were
given light intensity discrimination training according to
different sequences of S+ and S- trials. One group of
pigeons received nine S+ trials followed by nine S- trials
each day (hereafter refered to as group AE). A second group
received the reverse sequence; that is nine S- trials
followed by nine S+ trials daily (group EA). These two
groups were compared with a control group (group R) which
received interspersed S+ and S- trials. Generalization
gradients indicated that the characteristics of the PDG were
obtained only for the EA and R groups. Likewise, when the
EA and AE groups were transfered to the interspersed
sequence of S+ and S-, only group EA exhibited differential
responding or stimulus control. Therefore even though all

groups came to respond at a substanial rate during S+
presentations and at a much reduced rate during the S-,
only the groups which received an S-S+ transition within
the daily session produced a PDG and indicated no decrement
in differential responding when later transfered to the
random presentation of stimuli.

Implications for discrimination theory. The lack of
stimulus control shown by subjects trained under the AE
condition has potentially farreaching implications for any
theory of discrimination. If the locus of the AE effect is
determined by the particular sequence of the discriminanda
(the stimuli presented on the key), then present day dis-
crimination theories would have to be modified to account
for stimulus sequences. If, however, the locus of the AE
effect was not in the order of stimulus presentations but
instead was dependent upon events correlated with the stimuli
on the key, then the Ellis finding would not call for such
drastic theoretical changes. Possible correlated events
would include response rate, temporal factors, and the
reinforcing stimulus. The present investigation manipulated
the latter event (the reinforcing stimulus) in an attempt
to determine if the AE effect is dependent upon the stimulus
sequences per se or is determined by the correlation of the
stimulus and the reinforcing event.

Reinforcement as a Discriminative Stimulus

Discriminative properties between stimulus periods.
Differential responding evident during training for the AE
subjects coupled with the lack of intensity control during
generalization testing and transfer, indicates that some
other source(s) of stimulation were controlling responding.
Consider for a moment the role of the reinforcing stimulus
for the AE subject. Since reinforcement was scheduled on
a variable time base, an AE subject might have operated
under a rule which terminated responding only after a period
of time elapsed without reinforcement which was longer than
the longest inter-reinforcement interval characteristic
of the VI 1 minute program. If this rule were correct,
the different light intensities for the S+ and S- would
be redundant and little, if any, light intensity control
would develop. Evidence from Pavlov (1927) and Kamin (1969)
dealing with the overshadowing effect lends credence to
this point.

One method of reducing the cue value of reinforcement
between stimulus periods is to make the reinforcing stimulus
unreliable. That is, if reinforcement is scheduled only half
of the time during the S+, the subject is more likely to use
the key stimulus to modulate his responding in reference to
the S+ and S-. If reinforcement was the controlling stimulus
for the AE subject's behavior in the Ellis (1970) investigation
then by reducing the cue value of reinforcement between

stimulus periods with the above manipulation it would be predicted that a PDG and positive transfer would be obtained. For the present investigation, therefore, one group received a daily AE transition, one group a daily EA transition, and one group a random presentation of S+ and S- stimuli. Within the S+ trials, however, for half of the subjects only 50% of the trials terminated in reinforcement thereby reducing the discriminative properties of reinforcement between S+ trials. For the other half of the subjects, all S+ trials terminated with reinforcement (100% condition).

Discriminative properties within stimulus periods. The stimulus properties of a reinforcement may have contributed to Ellis' finding in another way, however. The standard procedure for the production of differential responding to stimuli is to present one stimulus (S+) for a constant period of time during which the subject may receive multiple reinforcements. Performance during the S+ stimulus is compared with performance in the presence of a different stimulus (S-) during which extinction is scheduled. Jenkins (1965) has noted that the control of responding by S+ is potentially confounded, after a reinforcement, with the stimulus properties of reinforcement. That is, after a reinforcment, the subject is no longer responding in the presence of the stimulus components comprising the S+ alone but also is responding in the context of the stimuli arising

from having received a reinforcement. Since no reinforcement
occurs during an S- period, the subject does not experience
a contextual difference during the S- stimulus period.
It is therefore evident that the S+ and S- are differentiated
not only by the physical stimulus difference but also by
a context difference.

Evidence of the discriminative properties of reinforcement.
Several studies have been reported which have investigated
the effect of an S+ trial on subsequent responding. Jenkins
(1965) devised a procedure whereby the S+ and S- alternated
on odd trials, while stimuli on even trials were selected
randomly. If the previous trial had been an S- the present
trial response probability was found to be lower and response
latency longer than if the previous trial had been an S+.
Using rats as subjects, Pierrel and Blue (1967) reported
results essentially identical to Jenkins in that "response
probabilities in S^{Δ} are higher following S^{D} intervals con-
taining reinforcement than in S^{D} intervals following other
$S^{\Delta}s$." (p. 549) McCullough (1968) replicated the Jenkins
result and added that the response probability increased
on S+ and S- trials even if a noncontingent reinforcement
was presented during the intertrial interval.

One procedure to eliminate the cue function of rein-
forcement within a stimulus period is to schedule rein-
forcement only at the end of the period. That is, if rein-
forcement is delivered only at the termination of the S+

interval no post reinforcement responding within the S+
period is possible. Therefore the context during which
responding occurs during S+ and S- is determined solely
by the stimulus present on that particular trial and is
not confounded by the presentation of reinforcement.

<center>Experimental Plan and Hypothesis</center>

The present study sought to investigate discrimination
formation using a discrete trial procedure. Briefly,
this procedure involves stimulus periods which are variable
in length but with an average duration of 60 seconds.
Each period is seperated from other periods by a 5 second
time out. If a reinforcement is scheduled to occur in
the presence of a particular stimulus, the reinforcement
is delivered if a peck occurs within ten seconds of the
termination of the period. After reinforcement, the operant
chamber is darkened and the time out initiated.

Specificily, the present investigation sought to
further examine the role of stimulus sequences in the
acquisition and generalization of stimulus control. How-
ever, the procedure employed has the effect of eliminating
the discriminative properties of reinforcement within a
trial by scheduling reinforcement at the trial's termination.
Further, the cue value of reinforcement is manipulated
between stimulus periods by the scheduling of reinforcement
on a random half of the S+ periods for one set of groups
thereby making the reinforcing stimulus less reliable as

a cue for differential responding. The performance of these so called 50% groups will be compared with groups receiving reinforcement at the termination of all S+ trials, i.e. the 100% conditions.

If the differential sequence effects reported by Ellis (1970) are replicated by the 100% conditions while being abolished by the 50% conditions, the implication would be that Ellis's result was due to the discriminative properties of reinforcement between stimulus periods. Further a more molecular analysis of behavior, not reported by Ellis, including sequential dependencies, rates of responding for successive S- periods, etc. was made with an eye toward possible sources of controlling stimuli within the special sequences.

C H A P T E R II
PROCEDURE AND DESIGN

Subjects. Twenty-four male White Carneaux pigeons,
6 - 12 months old obtained from Palmetto Pigeon Plant were
used as subjects (Ss). After arrival at the laboratory
all Ss were housed individually and given several days
of free-feeding in order to obtain stabilized body weights.
All Ss were then deprived of food and reduced to 75% of
their free-feeding weight. Each S was maintained at this
deprivation level until key peck training was completed.
At this time each S's weight was increased to 80% of their
free-feeding weight and maintained at this level throughout
the remainder of the experiment. If necessary, supplemental
feedings were given approximately thirty minutes after the
completion of the daily session for each group so as to
maintain the appropiate deprivation level.

Apparatus. Three identical Lehigh Valley Electronics
pigeon operant chambers and accompanying sound attenuating
hulls were used. Each hull was equipped with a blower so
as to provide adequate ventilation. A masking noise at a
sound level of 85db was delivered through a speaker mounted
on the front wall. Located centrally on the front wall,
approximately four inches above the floor, was a feeder
aperture which, when reinforcement was programmed to occur,
was lighted and grain reinforcement presented for 4 seconds.
Two pecking keys, five inches apart, were located six inches

above the feeder aperture. Only the right hand key was operative in the present experiment. The stimulus that transilluminated the key was selected from one of the twelve 6 volt lamps contained in an Industrial Electronic Engineers In-Line Display Cell located behind the key. The stimuli differed only in intensity and were generated by means of neutral density filters trimmed up with poten- tiometers in series with the lamp filaments. The seven intensities chosen were:

$$S1 = 35.61 \text{ ftc}$$
$$S2 = 22.46 \text{ ftc}$$
$$S3 = 14.17 \text{ ftc}$$
$$S4 = 8.94 \text{ ftc}$$
$$S5 = 5.64 \text{ ftc}$$
$$S6 = 3.56 \text{ ftc}$$
$$S7 = 2.25 \text{ ftc}$$

The values were checked frequently by means of a Photovolt Light Meter and corrected if any discrepancy occurred. These stimuli were chosen due to approximate spacing on a loga- rithmic scale. For all Ss, S4 was the S+ and S2 the S-.

Besides the key stimulus, the operant chamber was illuminated by a house light centered on the front wall and 1 inch from the ceiling. The house light was illuminated during all stimulus on periods and extinguished during a 5 second time out (TO) which separated the trials. Standard relay and timing equipment was used to schedule all events.

The measure of S's behavior was the number of responses in each stimulus period. The data was collected on printing counters and later converted to responses per minute.

Procedure

Pretraining. All Ss were habituated to the chamber for approximately 5 minutes on the first two pretraining days. On Day 3, Ss were magazine trained with 35 feeder presentations. The house light provided the only illumination during these three sessions. On the fourth day, key peck traning was accomplished by the method of successive approximations. During key peck training and all ensuing days until the beginning of discrimination training the S+ intensity was the only stimulus present on the key. Following key peck training, three days of continuous reinforcement (30 reinforcements per day) were given. For the next ten days, all Ss were given VI training. The VI schedule had a mean interreinforcement interval of 15 seconds (VI 15 sec) for two sessions followed by one session of VI 30 seconds and finally seven sessions of VI 60 seconds. Each session consisted of 30 stimulus periods, each variable in length, separated by a 5 second TO. The length of each stimulus period was determined by a VI 60 second schedule with the interval lengths obtained from the Fleshler and Hoffman (1962) series.

With the institution of the VI schedules a discrete

trial procedure was begun. This procedure scheduled reinforcement only at the end of the stimulus period if and only if a response occurred within 10 seconds (limited hold). With the termination of the response or the limited hold, a 5 second TO was initiated during which all lights in the chamber were extinguished. With the termination of the TO, the house light and key light were illuminated and another trial begun. This procedure precluded post-reinforcement responding within a stimulus period since reinforcement occurs at no other time than at the termination of the trial. The discrete trial procedure was used throughout the remainder of the experiment.

Six groups of four animals each were required for the present experiment. These groups were formed by matching response rates on the third and fourth days of VI 60 training. Matching necessitated the changing of the daily running order for some Ss. Since it was anticipated that this manipulation might disrupt responding somewhat, matching was completed early in VI 60 training. A comparison of performance among the groups over the last two VI 60 days indicated that no change in group assignment was necessary.

Special sequence training. The basic design of the present investigation was a 2 X 3 factorial with stimulus sequence as one factor (3 levels) and probability of reinforcement (2 levels) during S+ as the other factor.

All groups were given fifteen days of discrimination

training with each group receiving the appropiate stimulus
sequence and reinforcement percentage. Stimulus generaliza-
tion tests were given after Days 1, 3, 7, 11, and 15 of
discrimination training.

Groups R 100 and R 50 received a random order of S+
and S- trials with 32 daily stimulus periods. The stimulus
order was: + + - - - + + - - + + + - + - + - - + + + - - +
+ - - - + - + - . This sequence contains 7 + + transitions,
7 - - transitions, 9 + - transitions, and 8 - + transitions.
Group R 100 received reinforcement at the end of each S+
period while for Group R 50 reinforcement was scheduled for
a random half of the trials. In order to reduce the possibility
that Ss would learn the pattern of reinforced and nonreinforced
S+ trials, all the S+ trials reinforced on odd days were
nonreinforced on even days.

Group AE 100 and AE 50 received 16 stimulus periods
daily. Eight S+ periods preceded eight S- periods with 100%
reinforcement in S+ for AE 100 and a random 50% reinforcement
for AE 50. As with Group R 50, reinforced and nonreinforced
S+ periods were alternated each day for Group AE 50.

Eight S- periods followed by eight S+ periods were
scheduled for Groups EA 100 and EA 50. The same reinforcement
contingencies and patterns were operative in these latter
two groups as in AE 100 and AE 50.

It should be noted that in Groups AE 100 and AE 50 there
is only one + - transition per day while in Groups EA 100

and EA 50 there is only one - + transition per day. All
four of the above groups receive 7 + + and 7 - - transitions
daily which is identical to the number of like transitions
in Groups R 100 and R 50.

Stimulus generalization (SG) tests. During SG tests
the discrete trial procedure was still operative; however,
no reinforcements were programmed. Each test consisted of
42 stimulus periods (7 stimuli each presented 6 times) in a
random order. The length of each stimulus period was
variable and corresponded to intervals obtained from the
Fleshler and Hoffman series.

Transfer. On the day following the fifth SG test,
Groups AE 100, AE 50, EA 100, and EA 50 were transfered to
the random sequence of S+ and S- trials which had characterized
the R 100 and R 50 groups since the beginning of training.
Each S experienced the same reinforcement percentage in the
transfer phase as in the initial discrimination training.
This transfer phase was conducted to ascertain if the S+ and
S- had gained external stimulus control during the initial
stage of special sequence training. Positive transfer to the
random stimulus order would be indicative of external stimulus
control gained in the special sequence training. The transfer
phase continued for eight days with generalization tests
after Days 4 and 8.

C H A P T E R III
RESULTS

Over the last two days of VI training the response rate
for all groups had stablized at about 43 responses/min.
An analysis of responding during these two days indicated
that the groups did not differ ($F < 1$), nor was there a
significant effect of days ($F < 1$).

Special Sequence Training

Acquisition. The mean response rate per stimulus on
each day of acquisition for all groups is shown to the left
of the vertical line in Figure 1. The upper panel shows the
performance for groups receiving 100% reinforcement during S+
while the lower panel indicates performance for the 50% S+
reinforcement groups. Over days, the Ss within all groups
increased their response rate in the presence of S+ and de-
creased their rate during S-. The results of an analysis
of variance indicates a highly significant Days X Stimuli
interaction, $F(14,252) = 23.33$, $p < .001$. Since Days and
Stimuli did not interact with either Sequence ($F = 1.35$) or
Percentage ($F < 1$) it can be concluded that the S+ and S-
rates diverged at the same rate for all groups. However
considering only the last three days of acquisition when
performance was asymptotic, a significant Stimuli X Sequence
interaction was evident, $F(2,18) = 6.17$, $p < .01$. Inspection
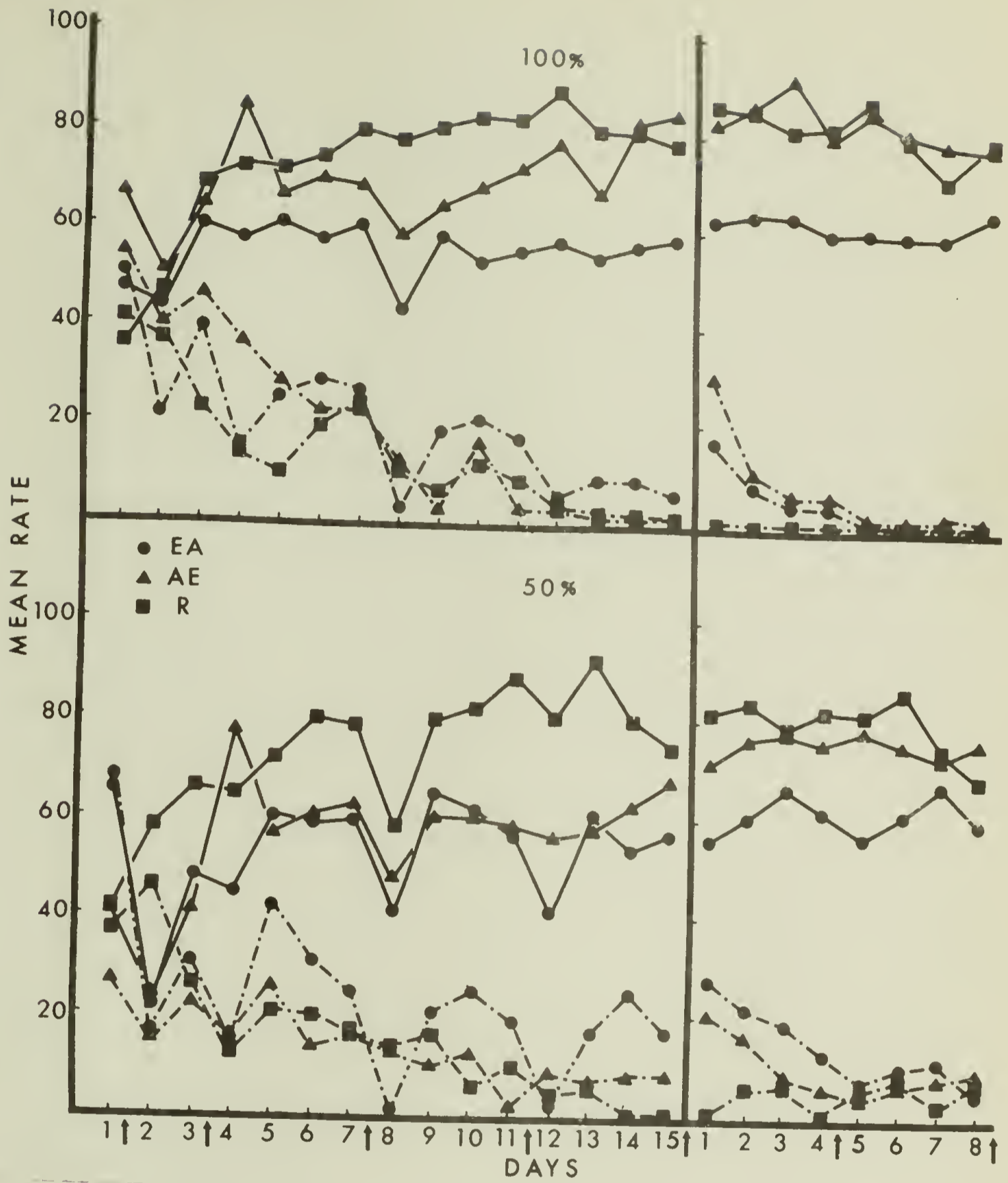of Figure 1 indicates that while the S- rates were nearly

Figure 1. Mean Rate of Responding for all Conditions
Over the Days of Special Sequence and
Transfer Training.

equal for all groups, the S+ rate was lower for the EA conditions (particularly with 100% reinforcement) than for the other sequences.

The only other significant effect during the last three days was that of Stimuli, $F(1,18) = 219.11$, $p < .001$. The lack of a significant Days X Stimuli interaction ($F < 1$) indicates stability among the various groups.

Generalization. The generalization gradients plotted in terms of mean responses/min. for the five tests conducted during special sequence training are shown in Figure 2. On the left appears the gradients for those sequences receiving 100% reinforcement while on the right are the gradients from the 50% conditions. All groups display similarly shaped asymmetrical gradients, that is a higher response rate to stimuli to the right of S+ than to the left of S+. Thus, there was no significant effect on generalization due to special sequences. Also the total response rate over all stimuli seems not to be affected by percentage of reinforcement as a partial reinforcement analysis would indicate.

The results of an analysis of variance indicates a significant Stimulus effect $F(6,108) = 35.73$, $p < .001$ which varied as a function of Sequence $F(12, 108) = 2.90$, $p < .005$ and across Tests, $F(48,432) = 2.81$, $p < .001$. Simple effects tests indicated that the R group differs significantly from the Special Sequence groups across Stimuli, $F(6,108) = 5.34$, $p < .001$ and across Tests, $F(24,432) = 2.16$, $p < .001$ while
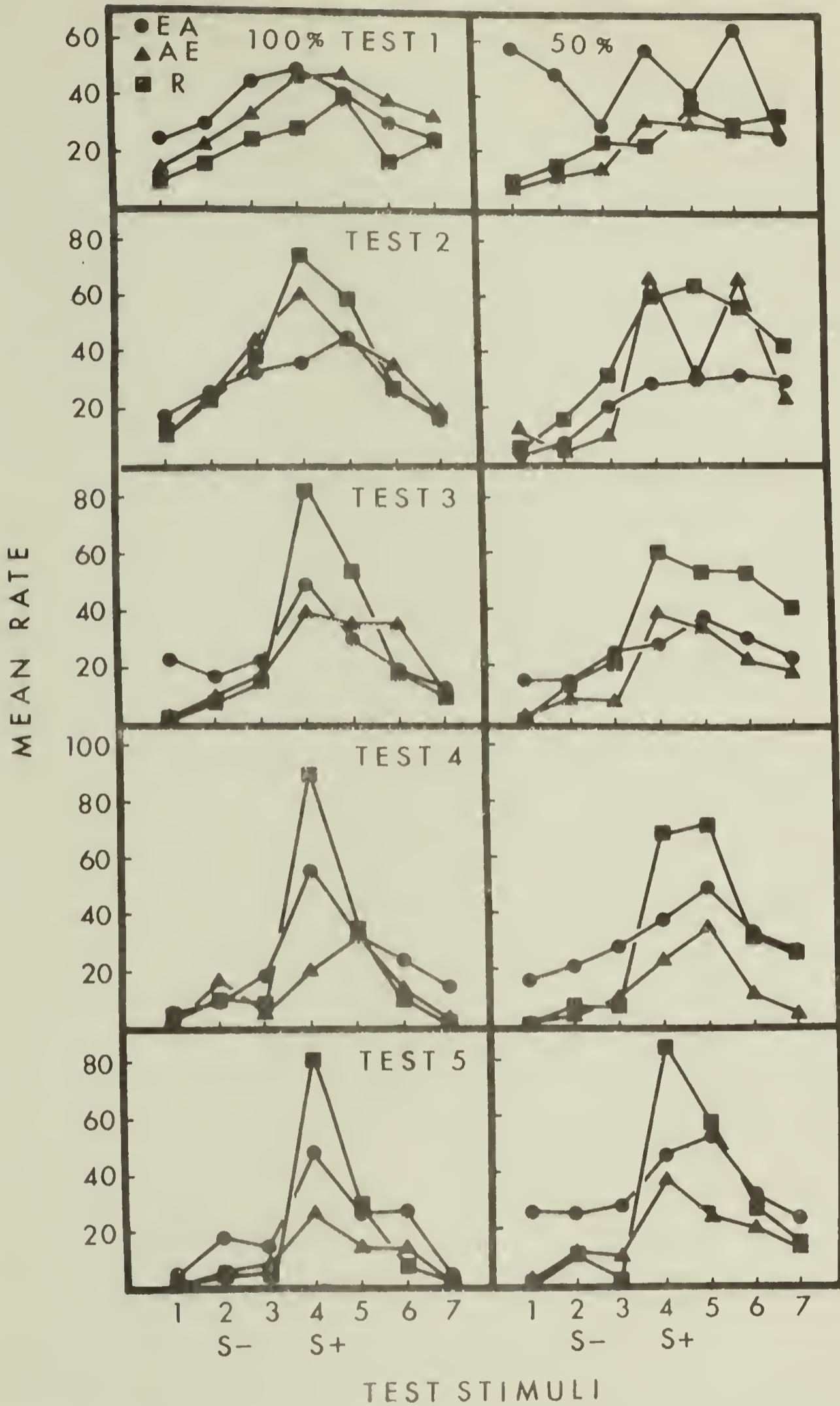
Figure 2. Mean Rate of Responding Per Stimulus During First Five Generalization Tests.

the two Special Sequence groups do not differ ($\underline{F}$s < 1).

Conditional Rates. Table 1 indicates the response rate on the present trial as a function of the immediately preceding trial for the Random group averaged over the last three days of acquisition training.

TABLE 1

CONDITIONAL RATE OF RESPONDING OVER THE LAST
THREE DAYS OF SEQUENCE TRAINING FOR
THE RANDOM SEQUENCE.

Present Trial	Preceding Trial	
	S+	S-
S+	70.42	88.67
S-	2.29	2.33

An analysis of variance indicates a significant effect due to the present stimulus (S+ vs S-), $\underline{F}(1,6) = 76.16$, $\underline{p} < .001$ and to the preceding stimulus, $\underline{F}(1,6) = 10.55$, $\underline{p} < .025$. Reference to Table 1 indicates that the response rate was higher on the present trial if the preceding trial had been an S- than if the trial had been an S+.

Successive S- Presentations. Considering for a moment only the EA and AE sequences, Figure 3 illustrates the mean
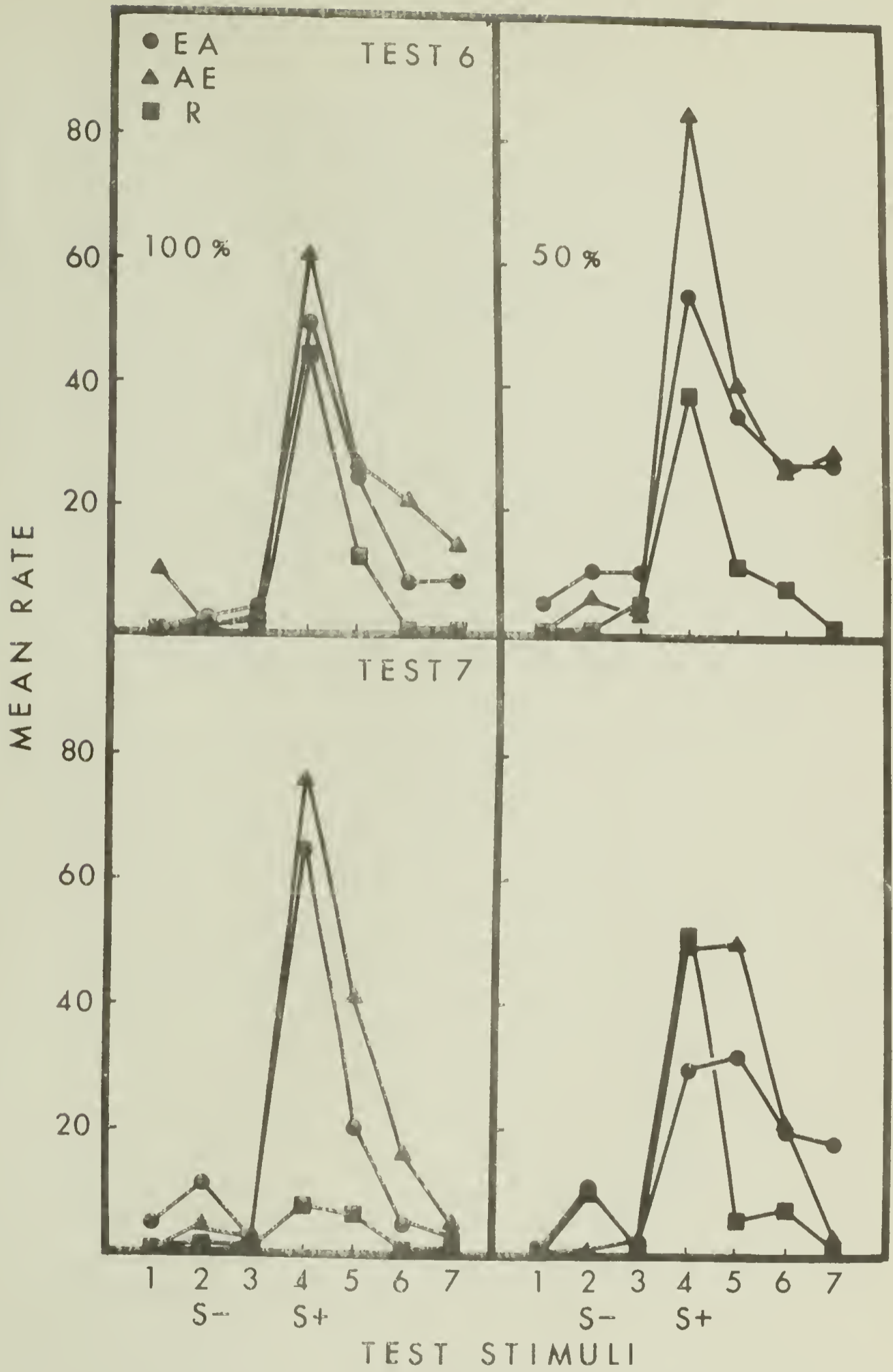
Figure 3. Mean Rate of Responding Per Stimulus During Last Two Generalization Tests.

response rate for each S- presentation over the last three acquisition days. While the S- rate for the AE group remains stable, the S- rate for the EA group gradually increases until the 8th period at which point there is a decrease. The decrease in the 8th period is due to a short (3 sec.) stimulus period during which the latency of the first key peck exceeded the length of the stimulus period for some birds.

Transfer to the Random Stimulus Sequence

Response Rates Per Stimulus. The right panel of Figure 1 illustrates the mean response rate for each stimulus for each day of the transfer phase. Of most importance is the performance on the first transfer day. While the rates during S+ for all groups and the S- rate for the Random groups remained unchanged, the S- rate for the Special Sequence groups increased. Comparing the increase from the last acquisition day to the first transfer day it was found that the EA 100, EA 50, and AE 50 increased 11.00, 11.00, and 12.50 responses per minute respectively. In contrast, subjects comprising the AE 100 group increased their response rate 29.00 responses per minute on the average. The larger S- rate increase for the AE 100 condition would indicate reduced external stimulus control for these subjects. This point will be considered later.

The starting speeds (latency of the first response) of the EA 100 and AE 100 subjects for those S- trials with stim-

ulus periods long enough (greater than 60 seconds) to give
reliable estimates of the latency indicates that the starting
speed for the AE 100 subjects was greater (17.60 seconds)
than for EA 100 subjects (10.56 seconds). When the latency
was subtracted from the length of the stimulus period and
the resulting time interval used to compute a corrected
response rate, no substantial rate differences remained
(EA 100 = 22.21, AE 100 = 27.57).

Partition of the variance indicates that the Random group
differed from the special sequence groups across Days and
Stimuli, $F(1,8) = 12.84$, $p < .005$. Percentage of reinforcement
interacted with Days and Stimuli for both the Random group,
$F(1,18) = 10.91$, $p < .005$ and for the partition of AE vs EA,
$F(1,18) = 7.08$, $p < .025$.

Transfer generalization tests. Generalization tests
were administered following 4 and 8 days of transfer training.
The results of these tests are shown in Figure 4. The Random
group continues to steepen accounting for a significant
Sequence, $F(2,18) = 10.95$, $p < .001$ and Stimuli X Sequence
effect, $F(12,108) = 2.99$, $p < .005$. In fact, the subjects
in the R 100 group seem to be discriminating not only the
stimuli but also the generalization tests. As in the pre-
vious generalization tests, the special sequence training
seems to have a negligible effect on the generalization
gradient.

Conditional rates during transfer. Table 2 gives
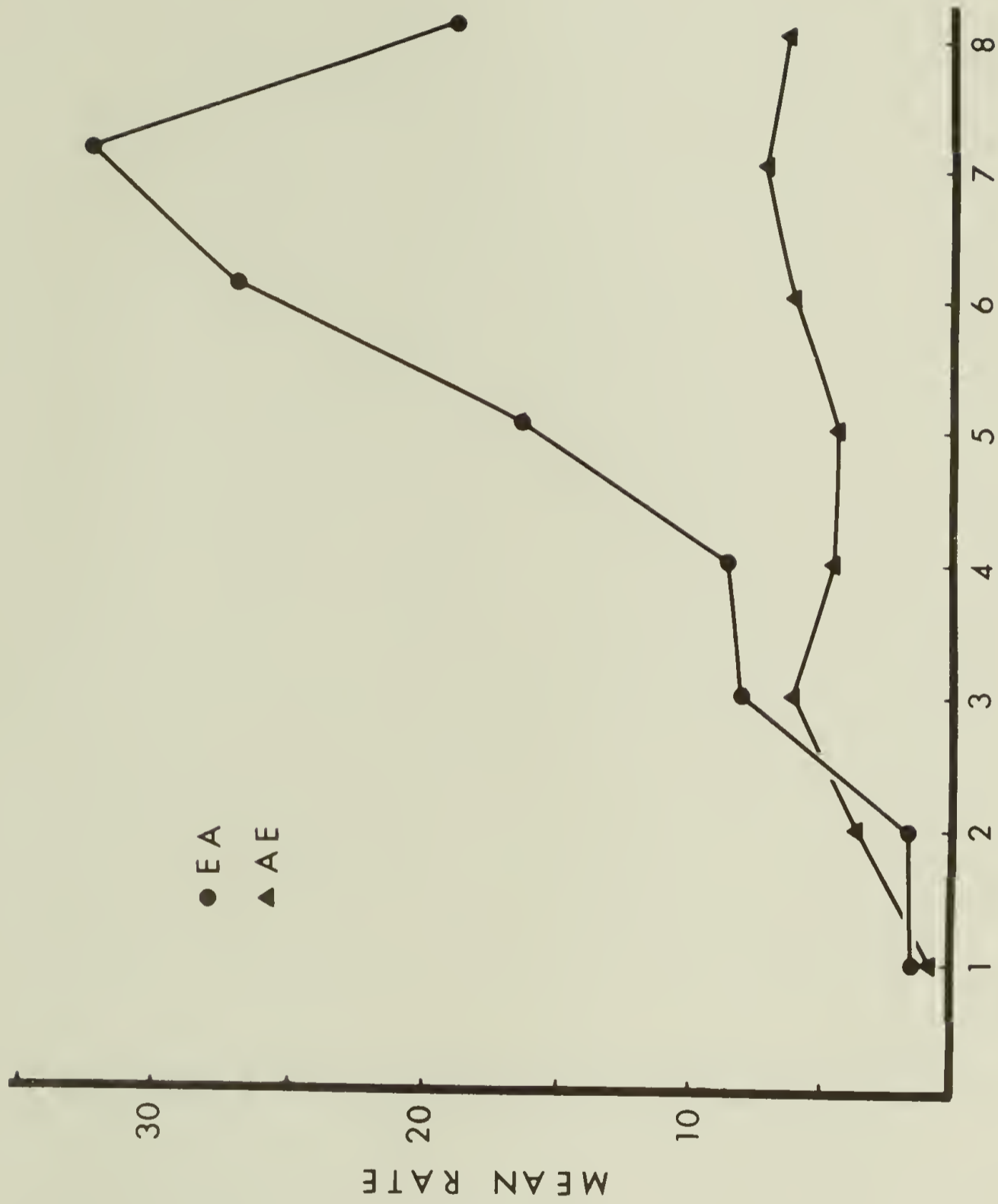
Figure 4. Mean Rate of Responding for Successive S-
Presentations for the EA and AE Sequences.

the response rate for the present trial as a function of
the preceding stimulus period for the three sequence conditions
averaged over the last three transfer days. Considering

TABLE 1

CONDITIONAL RATE OF RESPONDING OVER THE LAST

THREE DAYS OF TRANSFER FOR THE THREE

SEQUENCE CONDITIONS

| Present Trial | Preceding Trial | | | | | |
| | EA | | AE | | R | |
	S+	S-	S+	S-	S+	S-
S+	60.33	67.58	75.75	79.21	62.21	87.38
S-	3.54	6.42	3.33	8.13	2.54	4.04

all groups, the sequential effects were more pronounced for
the Random group than for the Special Sequence conditions.
Within the Random group, moreover, the effect of a preceding
S- trial on the present S+ trial was greater than a preceding
S- trial on a present S- trial.

That the preceding stimulus affected the Random group
differently than the Special Sequence conditions is indicated
statistically by a significant Preceding Stimulus X Random vs
Special Sequence interaction, $F(1,18) = 6.67$, $p < .025$ and
by the Preceding Stimulus X Present Stimulus X Random vs
Special Sequence interaction, $F(1,18) = 14.81$, $p < .001$.

C H A P T E R   IV

DISCUSSION

It will be remembered that Ellis (1970) found no
evidence of stimulus control for subjects trained according
to the AE stimulus sequence when they were shifted to a
random sequence of stimuli. No decrement was evident for
subjects trained with the EA sequence. It was the purpose
of the present investigation to manipulate the experimental
procedure to determine if the differential effect of AE and
EA sequences was due to event correlated with the discrim-
inada rather than with the sequence of the discriminada per
se. The primary finding of the present experiment would
indicate that one correlated event, the reinforcing stimulus,
contributed significantly to the AE effect found by Ellis.
That is, when the discriminative properties of reinforcement
are eliminated within a trial (AE 100 condition) the decrement
in external stimulus control on the first day of transfer
is attenuated while being completely abolished when the cue
value of reinforcement is controlled both within and between
stimulus presentations (AE 50 condition). Since the sequence
effects reported by Ellis are not due to the specific sequence
of discriminada, existing theories of discrimination need
not necessarily be revised to include statements concerning
the effect of stimulus sequence on the development of stimulus
control.

Stimulus control for the AE subjects. While stimulus
control was reduced in the AE 100 group on the first transfer
day, several lines of evidence are indicative of substantial
stimulus control produced by the AE sequence with the present
procedure. Specifically, during generalization testing it
was shown that the shape of the AE gradient was highly sim-
ilar to the gradient obtained from subjects trained under
the EA and R sequences. Furthermore, during the first S-
presentation of each AE session, the rate of responding was
low and equal to the rate generated by the EA subjects during
the comparable S- presentation. If the AE subjects were
solely under the control of stimuli associated with a
reinforcement, a high level of responding should have been
evident during these initial daily S- periods. This clearly
was not the case.

Stimulus control for EA and R subjects. The findings
from the generalization tests and the first transfer day
indicate that the discriminada on the key exerted considerable
stimulus control over the performance of the EA and R subjects.
During generalization testing, it was found that the gradient
of the Random group became steeper with each successive test.
Similar results have been previously reported by Hearst and
Koresko (1968) where it was found that the generalization
gradient steepened as the number of training days increased
and by Thomas and Barker (1964) where steepening of the gra-
dient was attributed to amount of generalization testing.

The S+ rate for the subjects trained with the EA sequence was found to be lower than the S+ rate for the AE and Random groups during both special sequence training and transfer. Since this lower rate was evident early in training (Day 3) and was maintained throughout the experiment, the effect is probably due to response rate conditioning. That is, since the S+ periods for the EA subjects followed eight periods of extinction, the response rate for initial S+ periods during the first few days of training would be low due to carry over of extinction effects. Reinforcement delivered during these S+ periods would have the effect of maintaining this lowered rate relative to the AE and Random conditions.

Conditional rates of responding. Jenkins (1965) reported a lower probability and a longer latency of the response on trials following S- trials than on trials following S+ trials. Pavlov (1929), however, reported evidence for what was termed positive and negative induction effects. Positive induction refered to the augmentation of the response to a stimulus which had been preceded by a negative stimulus while negative induction refered to a decrease of the response rate to a stimulus preceded by a positive stimulus. Results of the present investigation are consistent with the Pavlovian induction analysis and counter to the findings of Jenkins. That is, responding was elevated on trials following S- presentations relative to trials following S+ presentations in the Random groups over the last three days of special

sequence training. The discrepancy between the Jenkins finding and the present results probably lies in the correction procedure employed by Jenkins. For Jenkins, if a response occurred on a S- trial, the trial was repeated. This might have the effect of eliminating the induction effects contributed by a preceding S- trial.

The reduced magnitude of sequential effects for the EA and AE conditions during transfer along with the reported finding by Honig, et al (1959) that no behavioral contrast was evident during post-discrimination generalization testing implies that experience with the four possible transitions of stimuli contributes, in part, to the magnitude of the observed induction effects. When only one S+ S- (AE) or one S- S+ (EA) transition is given daily, the development of the induction effects seems to be retarded.

Conclusions. In summary then, the present investigation has shown that when the two possible confoundings contributed by the reinforcing stimulus are eliminated, the differential sequence effects reported by Ellis (1970) are either attenuated or abolished. However the specific mechanism which operated in the Ellis investigation to produce the differential sequence effect is still a mystery. What is clear, however, is that the sequence effects found by Ellis are generated by events correlated with the discriminada and are not intrinsic to the specific sequence of the discriminada.

Implications for the discrete trial procedure. One final

comment should be made concerning the discrete trial procedure
employed in the present investigation. In the standard mult
VI EXT schedule typically employed in operant investigations,
the possibility of extraneous sources of controlling stimuli,
i.e. the reinforcing stimulus, is a potential source of serious
confounding as Jenkins (1965) has noted. By delivering rein-
forcement at the termination of a trial, as in the present
procedure, the discriminative properties of reinforcement
within a stimulus period are eliminated without a decrease in
reliability exhibited by the free-operant procedure, i.e.
generation of many responses and increased resistance to
extinction. Since the source of stimulus control of behavior
is restricted to the discriminada with the present procedure,
the analysis of sequential dependencies and post-discrimination
behavior becomes less troublesome.

APPENDIX

TABLE A

ANALYSIS OF VARIANCE FOR THE LAST TWO

DAYS OF VI 60 SEC. BASELINE

TRAINING

Source	df	MS	F
Between Subjects	23		
Sequence (A)	2	199.77	<1
Percentage (P)	1	22.69	<1
A X P	2	311.06	<1
Subj. within AP	18	864.76	
Within Subjects	24		
Days (D)	1	414.19	<1
D X A	2	381.94	<1
D X P	1	28.52	<1
D X A X P	2	891.65	<1
D X Subj. within AP	18	948.98	

TABLE B

ANALYSIS OF VARIANCE FOR RESPONSE RATE

DURING SPECIAL SEQUENCE TRAINING

Source	df	MS	F
Between Subjects	23		
Sequence (A)	2	2859.93	<1
Percentage (P)	1	1394.45	<1
A X P	2	2303.40	<1
Subj. within AP	18	5256.37	
Within Subjects	696		
Days (D)	14	1001.70	2.21**
D X A	28	590.68	1.30
D X P	14	273.26	<1
D X A X P	28	216.71	<1
D X Subj. within AP	252	452.91	
Stimuli (S)	1	373,828.94	157.39****
S X A	2	10,231.79	4.30
S X P	1	1,211.61	<1
S X A X P	2	199.90	<1
S X Subj. within AP	18	2,375.06	
D X S	14	4,194.18	23.33****
D X S X A	28	243.91	1.35
D X S X P	14	138.40	<1
D X S X A X P	28	75.68	<1
D X S X Subj. within AP	252	179.71	

**** $p < .001$

** $p < .01$

TABLE C

ANALYSIS OF VARIANCE FOR RESPONSE RATES

OVER THE LAST THREE DAYS OF

SPECIAL SEQUENCE TRAINING

Source	df	MS	F
Between Subjects	23		
Sequence (A)	2	463.63	< 1
Percentage (P)	1	58.78	< 1
A X P	2	337.55	< 1
Subj. within AP	18	795.92	
Within Subjects	120		
Days (D)	2	7.38	< 1
D X A	4	239.45	2.37
D X P	2	137.13	1.36
D X A X P	4	32.25	< 1
D X Subj. within AP	36	100.74	
Stimuli (S)	1	142,003.36	219.11****
S X A	2	4,000.01	6.17**
S X R vs Spec	1	4,745.00	7.32*
S X AE vs EA	1	3,255.01	5.02
S X P	1	981.78	1.51
S X A X P	2	463.26	< 1
S X Subj. within AP	18	648.07	
D X S	2	27.55	< 1
D X S X A	4	123.35	3.01
D X S X P	2	121.30	2.95
D X S X A X P	4	8.18	< 1
D X S X Subj. within AP	36	40.98	

**** $p < .001$

** $p < .01$

* $p < .025$

TABLE D

ANALYSIS OF VARIANCE FOR SPECIAL SEQUENCE

TRAINING GENERALIZATION TESTS

(RESPONSES PER MINUTE)

Source	df	MS	F
Between Subjects	23		
Sequence (A)	2	5671.08	< 1
Percentage (P)	1	1860.12	< 1
A X P	2	1597.29	< 1
Subj. within AP	18	5890.26	
Within Subjects	816		
Tests (D)	4	4179.33	3.46*
D X A	8	2386.42	1.97
D X P	4	885.57	< 1
D X A X P	8	465.05	< 1
D X Subj. within AP	72	1206.71	
Stimuli (S)	6	24,366.22	35.73****
S X A	12	1980.19	2.90***
S X R vs Spec	6	3643.00	5.34****
S X AE vs EA	6	317.37	< 1
S X P	6	1818.20	2.66*
S X A X P	12	454.65	< 1
S X Subj. within AP	108	681.77	
D X S	24	720.23	2.81****
D X S X A	48	458.42	1.79**
D X S X R vs Spec	24	552.03	2.16****
D X S X AE vs EA	24	364.81	1.42
D X S X P	24	374.02	1.46
D X S X A X P	48	176.58	< 1
D X S X Subj. within AP	432	255.49	

**** $p < .001$ ** $p < .01$

*** $p < .005$ * $p < .025$

TABLE E

ANALYSIS OF VARIANCE FOR LAST DAY OF SPECIAL

SEQUENCE TRAINING VS THE FIRST

DAY OF TRANSFER

Source	df	MS	F
Between Subjects	23		
Sequence (A)	2	528.79	1.40
Percentage (P)	1	128.34	< 1
A X P	2	225.88	< 1
Subj. within AP	18	376.21	
Within Subjects	72		
Days (D)	1	1283.34	6.23*
D X A	2	90.13	< 1
D X P	1	44.01	< 1
D X A X P	2	10.79	< 1
D X Subj. within AP	18	205.75	
Stimuli (S)	1	90,712.51	316.92****
S X A	2	2,628.29	9.18***
S X R vs Spec	1	3,735.58	15.81****
S X AE vs EA	1	1,521.00	5.31
S X P	1	490.51	1.71
S X A X P	2	57.04	< 1
S X A X Subj. within AP	18	286.23	
D X S	1	225.09	8.43**
D X S X A	2	371.38	13.91****
D X S X R vs Spec	1	642.74	12.84***
D X S X AE vs EA	1	100.00	3.74
D X S X P	1	68.34	2.56
D X S X A X P	2	92.62	3.47***
D X S X P X R vs Spep	1	291.25	10.91
D X S X P X AE vs EA	1	189.06	7.08*
D X S X Subj. within AP	18	26.68	

**** $p < .001$ ** $p < .01$

*** $p < .005$ * $p < .025$

TABLE F

ANALYSIS OF VARIANCE FOR TWO GENERALIZATION

TESTS DURING TRANSFER PHASE

Source	df	MS	F
Between Subjects	23		
Sequence (A)	2	5628.27	10.95****
Percentage (P)	1	1534.30	2.98
A X P	2	87.32	< 1
Subj. within AP	18	513.68	
Within Subjects	312		
Days (D)	1	887.25	1.57
D X A	2	18.08	< 1
D X P	1	457.33	< 1
D X A X P	2	809.43	1.43
D X Subj. within AP	18	564.25	
Stimuli (S)	6	15,085.45	55.40****
S X A	12	816.47	2.99***
S X P	6	233.33	< 1
S X A X P	12	318.07	1.16
S X Subj. within AP	108	272.26	
D X S	6	256.84	1.19
D X S X A	12	157.94	< 1
D X S X P	6	74.12	< 1
D X S X A X P	12	445.26	2.06
D X S X Subj. within AP	108	215.67	

**** $p < .001$

*** $p < .005$

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