

Differential eyelid conditioning to stimulus compounds as a function of temporal relations between stimuli.

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DIFFERENTIAL EYELID CONDITIONING TO STIMULUS COMPOUNDS
AS A FUNCTION OF TEMPORAL RELATIONS BETWEEN STIMULI

By

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Introduction

Hartman and Grant (1962) found a greater difference between CRs to the positive (CS^+) and negative (CS^-) CSs of classical differential eyelid conditioning at CS-UCS intervals of 800 msec. than at intervals of 400 and 600 msec. The interpretation of these results which they favored was a drop in the function for the CS^- due to continued accumulation of inhibition. The primary objective of the present experiment was to investigate this interpretation. Onsets and durations of elements of two-element compound CS^+ s and CS^- s were varied in a manner presumed to influence accumulation of the postulated inhibitory factor.

The experimental and control conditions of this experiment were such that three additional objectives could be investigated. The first was partial replication of Hartman and Grant's experiment. The second was to determine the effects on acquisition of positive stimulus intensity of one of the two elements of the compounds where groups were trained either to a high intensity CS_2^+ and low intensity CS_2^- or vice versa. The third objective was to determine relative frequencies of CRs to each of the elements of the CS^+ and CS^- during extinction

Hartman and Grant's results and the basis for their interpretation are described in greater detail as a background to the rationale for the design of the present experiment. The design is then presented.

Hartman and Grant.--In simple classical conditioning the optimal CS-UCS interval has proved to be between 400 and 500 msec.

(Kimble, 1947; McAllister, 1953). Extending the variable of the CS-UCS interval to classical differential eyelid conditioning, Hartman and Grant presented the CS^+ at intervals of 400, 600, 800, and 1000 msec. The CS^- was not accompanied by the UCS. Highest asymptotic response levels to the CS^+ occurred at the 600 msec. interval. The 800 msec. interval was next highest, followed by the 1000 and 400 msec. conditions. Lowest final response levels to the CS^- were observed at the 1000 msec. interval and highest at 600 msec. The 800 and 400 msec. intervals were second and third lowest, respectively. Differential responding, which is indicated by the difference in response levels to the CS^+ and CS^- , was optimal for the 800 msec. condition due to relatively high levels of CS^+ responding and low CS^- response levels. For the 1000 msec. interval differential responding was attenuated by low CS^+ levels and at the 600 msec. interval high levels of CS^- responding resulted in poorer differentiation. The 400 msec. condition was poorest in differential responding due both to low CS^+ and relatively high CS^- levels.

Hartman and Grant consider two explanations for the relatively long optimal interval for differential responding. The first of these involves more complete "perceptual responses" to the positiveness or negativeness of the CS which would be possible at longer CS-UCS intervals. The second is that the inhibition of a response requires a relatively long period of time, i.e., more time than is allowed at short CS-UCS intervals. This notion implies

that of the excitatory or "basic response" and inhibitory mechanisms operative in the production of a CR, the inhibitory mechanism is of longer latency. Hartman and Grant note that the optimal 800 msec. interval for differential responding was the result of more complete inhibition of responses to the CS^- at relatively long CS-UCS intervals since highest response levels to the CS^+ were observed at a shorter 600 msec. interval. This suggests to the authors that the second explanation is to be preferred, i.e., that the poorer differentiation at the short CS-UCS intervals was due to the relative absence of inhibitory factors whereas at longer intervals a more complex type of conditioning involving inhibition was taking place.

Rationale.--To investigate conceptions of Hartman and Grant in differential conditioning, onsets and durations of stimulus compounds were utilized for reinforced trials as in Figure 1. On nonreinforced trials to negative stimuli the UCS was omitted. For the control group (Group C), two auditory stimuli were presented singly as CS^+ and CS^- with a CS-UCS interval of 800 msec. on reinforced trials. For two groups, both auditory and visual stimuli (CS_1 and CS_2) were presented simultaneously, either at a relatively long 800 msec. CS-UCS interval (Group Sim-L) or at a 400 msec. interval (Group Sim-S). Sequential presentation of the compounds occurred for another group (Group Seq) with the auditory stimulus presented 400 msec. prior to onset of the visual stimulus which in turn preceded the UCS by 400 msec. on reinforced trials.

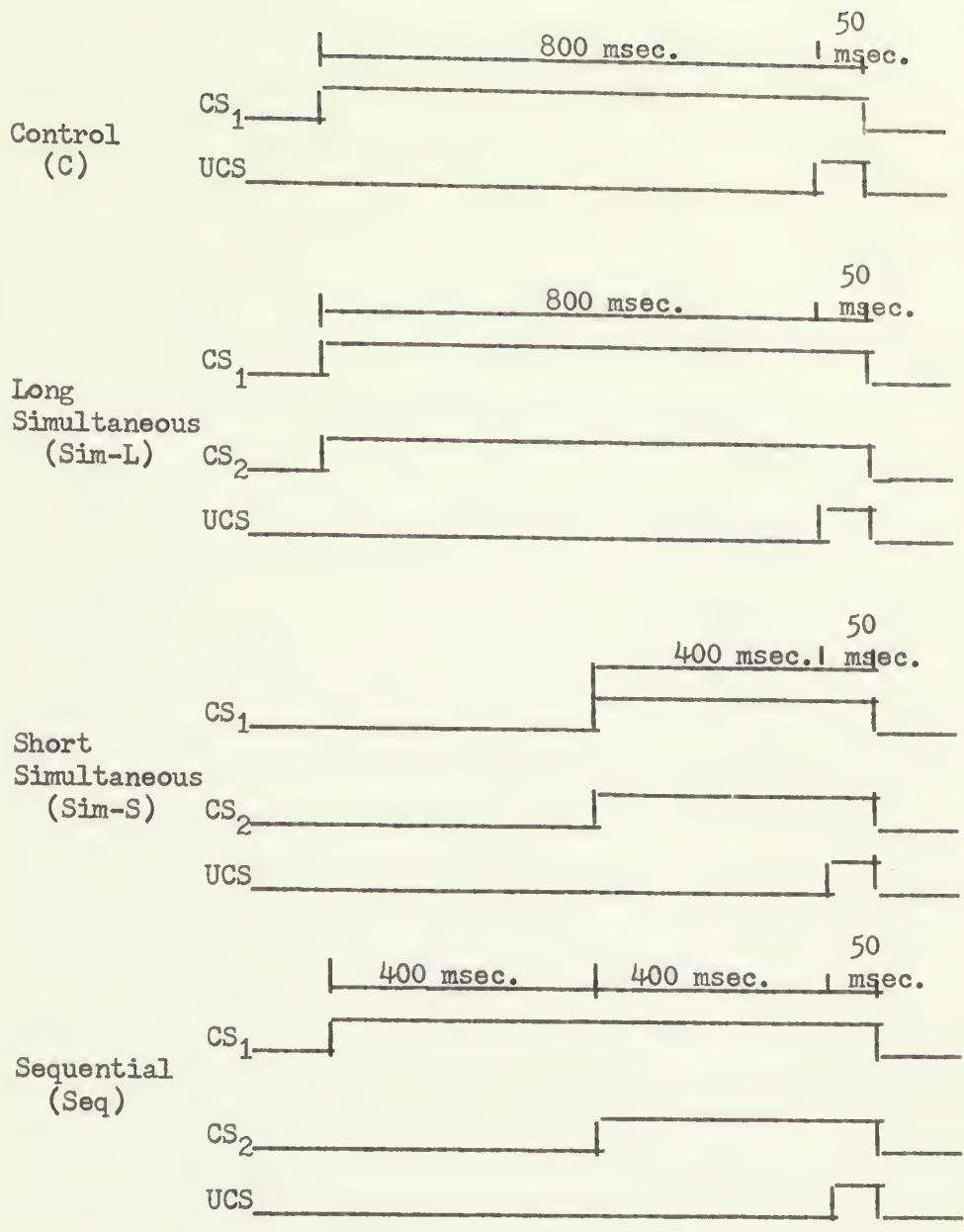


Figure 1. Temporal relations between stimuli designed to investigate Hartman and Grant (1962) conceptions of differential conditioning.

In this situation CS_1^+ and CS_1^- were highly similar so that generalization factors could be expected to attenuate differential responding in the case of the control group which received only these stimuli. The visual stimuli or CS_2 s were dissimilar so that the more distinctive compounds of $CS_1-CS_2^+$ and $CS_1-CS_2^-$ should lead to better differential responding than the control condition. According to conceptions of Hartman and Grant, however, this prediction is contingent upon a CS_2 -UCS interval of sufficient length to allow for inhibition of responses to the negative stimuli. Based on the results of the Hartman and Grant experiment, this interval should be of the order of 800 msec. The sequential group of the present investigation was utilized to test this hypothesis since the onsets of the CS_2^+ and the UCS are separated by 400 msec., which is not a sufficient interval to permit significant CS_2 contributions to the inhibitory process. The required interval conditions for CS_2 contributions to inhibition are, however, met for Group Sim-L in which both CS_1^+ and CS_2^+ are presented 800 msec. prior to the onset of the UCS on reinforced trials. Hartman and Grant's conceptions regarding inhibition would thus predict that differential responding should be improved over control conditions for Group Sim-L but not for Group Seq.

An additional objective of this experiment was the comparison of Group Sim-S with Group Sim-L. This constitutes a replication and extension to the stimulus compound situation of the 400 and 800 msec. interval conditions of the Hartman and Grant study. The

generality of those results would be verified by superior differentiation for the simultaneous-long group.

The effect of CS_2^+ intensity upon the acquisition of differential responding was also investigated. The two visual stimuli employed in this experiment consisted of increases in illumination of a milk glass disk to a high or low intensity. With each experimental condition (Sim-L, Sim-S, Seq) two groups were formed on the basis of whether the bright or dim light served as CS_2^+ . Hull (1943) postulates a stimulus intensity dynamism factor which is a positive monotonic function of the intensity of the conditioned stimulus. This factor is assumed to combine with the habit variable in a multiplicative relationship. In the present experiment this indicates that stimulus intensity will influence differential responding by raising response levels to the CS^+ for bright-positive groups and to the CS^- for dim-positive groups. Further, the multiplicative assumption predicts that the intensity effects will be greater for the positive stimuli which are characterized by higher levels of the habit factor. The net results of these influences should be superior differential responding for bright-positive groups, due primarily to increased CS^+ responding. These predictions have previously been verified in an investigation by Moore (in press) utilizing classical differential eyelid conditioning to various intensities of a tone serving as CS^+ and CS^- .

A final objective of the present experiment was to investigate the effects of temporal relationships between elements of the

7

compounds on response levels to the elements presented separately following acquisition. This represents a partial replication and extension to the differential conditioning situation of experiments by Wickens et. al. in simple classical conditioning to stimulus compounds (Wickens, 1959; Wickens & Cross, 1959; Wickens, Gehman & Sullivan, 1959). To accomplish this objective, each experimental group was subdivided into five extinction groups with one of these groups extinguished to the intact positive stimulus (CS^+) and the other four to one of the elements (CS_1^+ , CS_2^+ , CS_1^- , CS_2^-).

It is to be expected under these circumstances that response levels to the positive elements would in general be lower than would be observed to the intact positive stimuli (Hull, 1943; Pavlov, 1927). Predictions are not as clear with regard to the negative elements since decrements could be expected in both positive response tendencies and in inhibitory mechanisms due to the separation procedure. Under conditions of the present experiment in which the CS_1 s are similar and the CS_2 s are dissimilar, intuitive expectations might be that the more distinctive stimuli would become dominant as training progressed so that the CS_2^+ elements would display higher response levels than the CS_1^+ components. Spence (1960), in his treatment of stimulus patterning in the instrumental discrimination learning situation, postulates that the subject will respond to individual elements rather than patterns unless no one of the cue members is systematically

reinforced more than the others. In the present experiment both CS_1^+ and CS_2^+ are systematically reinforced. However, generalization factors between the more similar CS_1^s would be expected to partially negate the effects of reinforcement so that the emergence of a dominant CS_2^+ element is likely.

An added complication arises in the case of the sequentially-presented compounds. Wickens (1959) has shown in the simple conditioning situation that an initiating stimulus becomes dominant if the CS_1 - CS_2 interval is optimal for conditioning between the two to occur. Under these circumstances isolated presentation of the CS_1 apparently leads to some implicit reproduction of the entire stimulus chain with relatively little loss in response strength. If this finding has generality, it is to be expected that testing to elements will have differential effects upon the simultaneous and sequential compound groups. In the simultaneous groups if any element is to show dominance it should be the distinctive CS_2^+ . For the sequential condition, however, the highly similar CS_1^s should lead to better differential responding and higher CS^+ levels than the dissimilar CS_2 elements.

Method

Stimuli.--Conditioned stimuli presented first in the sequence of CS₁, CS₂, and UCS on reinforced trials consisted of the introduction of a tone of either 1000 or 950 cps at a level of 60 dbs. into a constant background level of 53 db. For nonreinforced trials, the tone which was not presented on reinforced trials served as CS₁⁻. These frequencies have been found to produce generalization of conditioned eyelid closure without significant decrement following a contrast training procedure (Hake, 1948). The CS₂'s were increases in brightness of a milk glass disk from 0.032 to 3.20 and 0.075 apparent ft.-candles. These stimuli are the extreme values in a generalization gradient which ranged from 90 to 10 per cent CRs when training was conducted to the 3.20 stimulus (Vandament & Price, 1964). Stimuli were counterbalanced so that an equal number of Ss in each of the experimental cells received each of the four possible CS₁-CS₂ combinations. The auditory stimuli were also counterbalanced for the control group so that each tone appeared with equal frequency as CS⁺. The UCS was an air puff of 2 psi delivered to the S's right eye.

Experimental Design.--Table 1 shows the control and experimental cells of this experiment. During acquisition seven conditions consisted of the control plus three levels of experimental condition (Sim-L, Sim-S, Seq) which were orthogonal to two levels of CS₂⁺ intensity.(Dim+, Bright+). For the control group, the CSs were tones of 850 msec. duration with an 800 msec. CS-UCS interval on

Table 1
Experimental Design for Acquisition
and Test-Extinction Trials

Acquisition

CS_2^+ Intensity	Experimental Group		
	Sim-L	Sim-S	Seq
Dim+	n=30	n=30	n=30
Bright+	n=30	n=30	n=30
Control	n=18		

Extinction

Acquis. Group	CS^+	CS_1^+	CS_2^+	CS_1^-	CS_2^-
Sim-L	n=12	n=12	n=12	n=12	n=12
Sim-S	n=12	n=12	n=12	n=12	n=12
Seq	n=12	n=12	n=12	n=12	n=12
Control	n=18				

reinforced trials. For the group trained to a lengthy simultaneous presentation of the stimulus compounds (Group Sim-L), both the CS_1 s and CS_2 s were of 850 msec. duration with a CS-UCS interval of 800 msec. on reinforced trials. The second simultaneous group (Group Sim-S) received trials with both CS_1 s and CS_2 s of 450 msec. duration and a CS-UCS interval of 400 msec. For the group trained to sequentially arranged stimulus compounds (Group Seq), CS_1 s and CS_2 s were of 850 and 450 msec. durations, respectively. This resulted in a CS_1 - CS_2 interval of 400 msec., a CS_1^+ -UCS interval of 800 msec., and a CS_2^+ -UCS interval of 400 msec. For all groups, the UCS was of 50 msec. duration and all stimuli terminated simultaneously on reinforced trials. For nonreinforced trials to the CS^- the UCS was omitted with CS durations remaining constant across reinforced and nonreinforced trials.

Following acquisition, the three experimental groups were further subdivided into five groups of 12 Ss each for test and extinction trials as shown in Table 1. Four groups within each of these experimental-acquisition conditions were extinguished to one of the four CS elements presented in acquisition, i. e., to CS_1^+ , CS_2^+ , CS_1^- , or CS_2^- . The fifth group within each experimental condition received test-extinction trials to the intact positive stimulus compound given during acquisition. The control group was given nonreinforced presentations of the CS^+ during extinction.

Subjects.--Subjects were 198 students from introductory psychology courses at the University of Massachusetts. Thirty Ss were randomly assigned to each of six cells in the experimental- CS_2^+

intensity conditions during acquisition. Eighteen additional Ss were assigned to the control group. Following acquisition, the three experimental groups were further subdivided into five groups of 12 Ss each for test and extinction trials as described previously. Taking into account all experimental- CS_2^+ intensity- CS_1^+ frequency-extinction combinations, three Ss were randomly assigned to each of 60 cells within the restriction that two males and one female appear in each cell. The 18 Ss of the control group were also assigned within the same sex restriction.

Apparatus.--Ss were seated in a dental chair located in a semi-darkened 6 ft. 6 in. x 7 ft. 5 in. room facing the stimulus unit, a 3 x 3 ft. flat black panel. Noise from a fan masked the various apparatus sounds from the adjacent E's room. The visual CSs were an increase from 0.032 to 0.075 or 3.20 apparent ft.-candles in the illumination of a circular milk glass disk, 6 cm. in diameter, located in the center of the stimulus panel. These values were obtained by means of a Variac transformer and Wratten neutral density filters. Auditory stimuli were generated by means of an Eico Model 377 audio-generator; the speaker was located directly behind the Ss chair. Air puff delivery was via a compressor-solenoid valve system leading to a nozzle of 1/16 in. diameter aimed at Ss right cornea. Duration of stimuli and the intervals between them were controlled by a series of Hunter interval timers. The inter-trial interval was controlled by a Gebrands programmer. The recording of the S's eyelid movements was by means of a micro-

torque potentiometer, Hunter amplifier, and Epsco permotor. The permotor was mounted on a Brush paper-puller which moved paper through the recording system at a rate of 120 mm. per second.

Procedure.--After the subject was seated in the dental chair and the recording and puff delivery apparatus had been attached, a standard set of instructions designed to induce a passive set were read (Appendix B). Eighty acquisition trials were then administered. Inter-trial intervals varied randomly from 10 to 20 sec. about a mean of 15 sec. On half of these trials the CS^+ was presented and on half the CS^- was presented. Occurrences of the CS^+ and CS^- were randomly presented within a restriction of equal numbers of occurrences in each successive block of 10 trials.

A series of 20 test-extinction trials began 15 sec. after the last acquisition trial. During these trials the UCS was omitted without changes in the CS durations.

Definition of Response.--Deflections of 1 mm. or more of the recording pen within a latency period of 200 msec. following CS onset to 50 msec. prior to CS offset were considered conditioned responses (CRs) during acquisition and, with one exception, during extinction. The 200 msec. latency criterion was discarded for Groups Seq- CS_2^+ and Seq- CS_2^- since CS_2 onset had already followed the start of the trial by 400 msec. during the acquisition phase. Since Hartman and Grant (1962) found that Ss with a response shape termed "voluntary" (Spence & Ross, 1959) differed from the majority of Ss in both CS^+ and CS^- inter-stimulus interval functions, a

criterion of 50 per cent or more responses with time derivatives (dx/dt) greater than 35 per cent of mean time derivative for the first five UCRs was used to eliminate "voluntary" responders from additional statistical analyses in acquisition (Hartman & Ross, 1961). For these analyses 19 Ss who met this criterion were discarded along with 19 other Ss eliminated to maintain cell proportionality.

Results

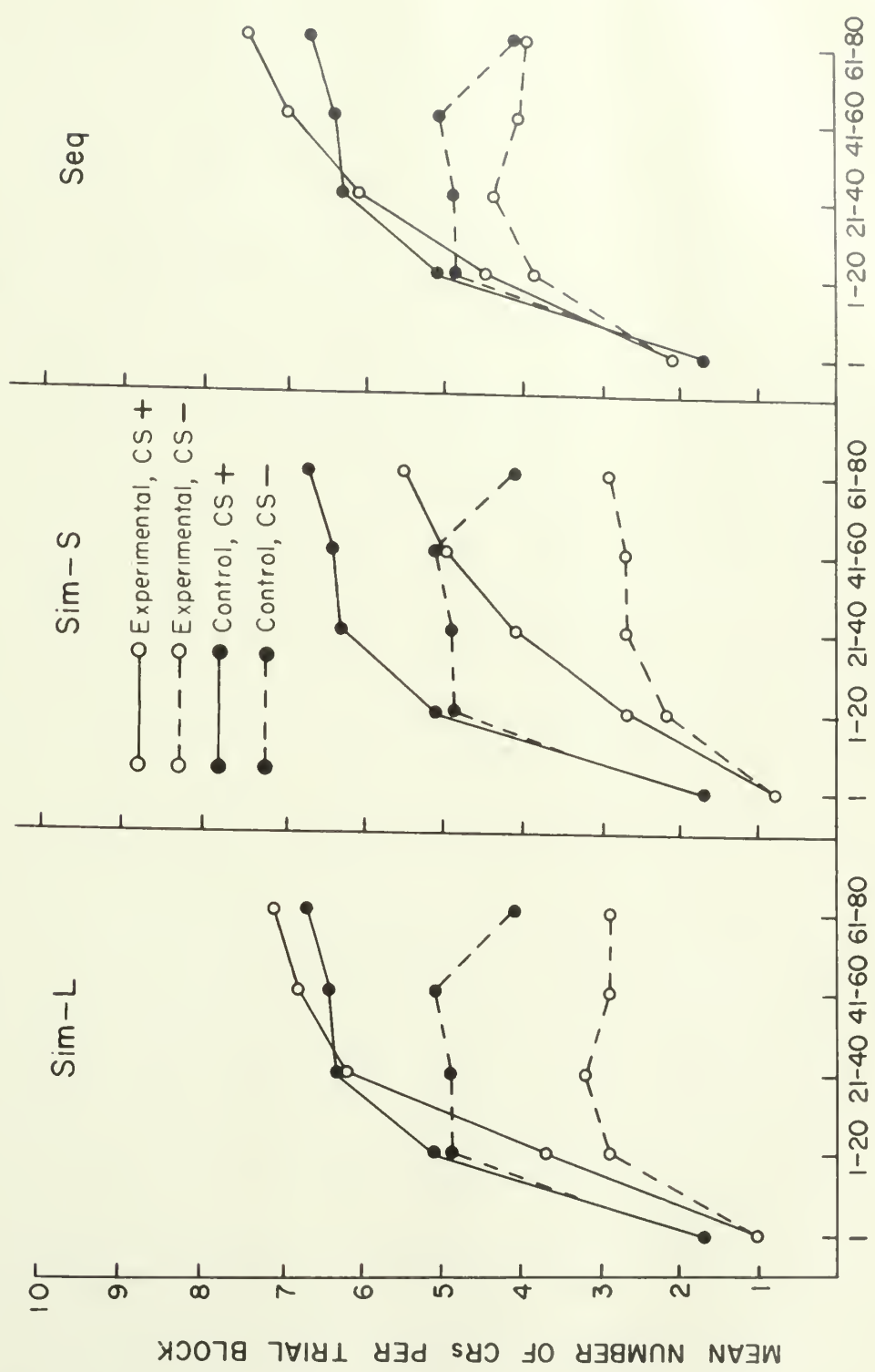
Separate statistical analyses were performed for acquisition trials, the first trial following acquisition, and all extinction trials. Analyses were carried out on protocols of all Ss and of those Ss classified as "nonvoluntary". Results of the latter are presented in Appendix D. These "nonvoluntary" analyses are in essential agreement with those presented in the text.

Acquisition.--Results were analyzed across all 80 and for the last 10 acquisition trials. Table 2 shows the means of the numbers of CRs given in successive blocks of 10 trials. These are plotted in Figure 2 for successive blocks of 20 trials for each of the experimental conditions compared to the control condition disregarding intensity of CS_2^+ . CRs to the CS^+ increased in a negatively accelerated fashion for both the experimental and control groups. The curve for the Seq condition is slightly above that for the Sim-L condition. Both overlap but end slightly above the curve for the control condition. All of these lie above the curve for Group Sim-S. CS^- curves within each group show slower initial increments than the CS^+ curves and, with the exception of Group Sim-S, the direction of the CS^- functions changed from positive to negative at some point during acquisition. The curve for the control condition reached a higher peak than the experimental curves and was characterized by a later change in direction and sharper post-peak decrements than the Sim-L and Seq curves. The latter two changed direction from positive to

Table 2

Means and Standard Deviation of Numbers of Crs to the
CS+ and CS- during Successive Blocks of 10 Acquisition Trials

Conditions and Intensity of CS ₂ +	Stimulus	Trials							
		1- 10	11- 20	21- 30	31- 40	41- 50	51- 60	61- 70	71- 80
Sim-L(D+)	CS+	M	1.03	1.83	2.13	2.57	2.97	3.13	3.20
		SD	1.69	2.76	3.09	3.22	2.52	3.22	2.99
	CS-	M	1.23	1.27	1.30	1.27	1.20	1.17	1.40
		SD	2.74	3.17	2.42	2.41	2.10	2.63	2.87
Sim-L(B+)	CS+	M	1.50	2.97	3.50	4.13	4.17	4.00	4.17
		SD	1.36	2.72	1.84	1.29	1.03	1.71	1.17
	CS-	M	1.63	1.77	1.70	1.53	1.33	1.50	1.63
		SD	1.27	1.77	2.22	1.36	1.82	1.50	1.55
Sim-S(D+)	CS+	M	.90	1.43	1.53	1.70	1.87	1.93	2.30
		SD	.99	2.05	2.05	2.15	2.19	2.41	2.22
	CS-	M	1.03	1.17	.97	1.13	.90	1.17	1.20
		SD	1.96	2.49	1.48	1.84	1.13	1.73	1.68
Sim-S(B+)	CS+	M	1.33	1.80	2.30	2.63	3.07	3.07	2.83
		SD	1.61	2.44	3.32	2.93	2.55	2.96	3.11
	CS-	M	.83	1.37	1.57	1.67	1.50	1.77	1.87
		SD	1.32	1.83	2.46	1.95	1.78	2.32	2.60
Seq(D+)	CS+	M	2.13	2.77	2.93	3.00	3.23	3.63	3.57
		SD	1.77	3.56	2.89	3.45	3.01	2.72	2.25
	CS-	M	2.53	2.83	3.10	3.13	2.90	3.03	3.07
		SD	2.60	3.18	3.33	2.67	2.85	3.00	2.34
Seq(B+)	CS+	M	1.70	2.47	3.03	3.30	3.30	3.87	3.80
		SD	2.70	3.91	3.17	3.73	2.36	2.33	2.44
	CS-	M	1.40	1.17	1.33	1.27	.73	1.43	1.23
		SD	2.87	2.14	2.23	1.79	.82	1.84	1.43
Control	CS+	M	2.00	2.67	2.72	3.44	3.00	3.06	3.28
		SD	3.41	3.88	3.51	1.32	3.64	2.88	2.68
	CS-	M	2.72	2.56	2.28	2.78	2.56	2.83	2.17
		SD	3.04	3.08	3.39	2.89	2.38	2.74	3.21



TRIALS

Figure 2. Means of numbers of CRs to the CS⁺ and CS⁻ in successive blocks of 20 acquisition trials for each of the experimental conditions compared to the control condition. The initial points were computed by multiplying the response probability on the first trial for each condition by 10.

negative during the third block of 20 trials with the curve for Group Seq consistently higher than the Sim-L curve. The CS^- curve for the Sim-S condition lies below all other curves and has a constant positive direction.

When the intensity of CS_2^+ is considered for experimental groups essentially the same patterns are obtained for the Sim-L and Sim-S conditions except that both CS^+ and CS^- curves are higher under the bright-positive condition. CS^+ functions display more marked increases due to the bright-positive conditions than do the CS^- s. For the sequential groups CS^+ curves were relatively unaffected by CS_2^+ intensity and CS^- responding was markedly suppressed under the bright-positive condition.

The analysis of variance on numbers of CRs given by each subject in successive blocks of 10 trials during acquisition is summarized in Table 4. In this analysis Conditions and CS_2^+ intensity (C-I) is a between Ss variable with Stimuli (CS^+ , CS^-) and Trials as within Ss effects. Seven levels of the C-I effect consist of the control group plus six experimental group (Sim-L, Sim-S, Seq)- CS_2^+ intensity (Dim+, Bright +) combinations. The Fs for Conditions and Intensity of CS^+ , Stimuli, and their interaction are based on CRs for all acquisition trials. In order to understand these Fs more easily, means of numbers of CRs to the CS^+ and CS^- for all acquisition trials for control and experimental conditions for which the CS_2^+ was bright or dim appear in Table 3.

Table 3

Means of Numbers of CRs to the CS⁺ and CS⁻ Separately
and Combined during all Acquisition Trials

Conditions	CS ₂ ⁺	CS ⁺	CS ⁻	Total	Difference
Sim-L	Dim	19.93	10.07	29.10	9.87
	Bright	28.60	11.97	40.57	17.63
	Both	24.27	11.02	35.28	13.25
Sim-S	Dim	14.20	8.67	22.87	5.53
	Bright	20.37	12.30	32.67	8.07
	Both	17.28	10.48	27.77	6.80
Seq	Dim	25.07	23.17	48.23	1.90
	Bright	25.23	9.70	34.93	15.53
	Both	25.15	16.43	41.58	8.72
Control	--	23.39	20.06	43.44	3.33

Table 4

Analyses of Variance on CRs during Acquisition and
Trials 71-80 using Data from All Subjects

Source	df	Acquisition		Trials 71-80	
		<u>MS</u>	<u>F</u>	<u>MS</u>	<u>F</u>
Conditions and Intensity of CS+ (C-I)	6	132.41	6.97***	10.94	3.65**
Error (b)	191	19.01		2.99	
Stimuli (St)	1	1006.88	272.11***	376.25	322.62***
Trials (T)	7	47.12	35.88***		
St x T	7	41.68	54.41***		
C-I x St	6	57.58	15.56***	10.67	9.51***
C-I x T	42	1.38	1.05		
C-I x St x T	42	1.67	2.18*		
<u>Ss</u> x St/C-I	191	3.70		1.17	
<u>Ss</u> x T/C-I	1337	1.31			
<u>Ss</u> x St x T/C-I	1337	.77			

* $p < .05$

** $p < .01$

*** $p < .001$

Means for the experimental conditions disregarding intensity of the CS_2^+ are also shown.

The significant F for Conditions and Intensity of CS^+ reflects differences in the total numbers of CRs among the seven levels of the C-I effect summing across both positive and negative stimuli. Most CRs were given in acquisition by Group Seq(Dim+) followed by Control, Sim-L (Bright+), Seq (Bright+), Sim-S (Bright+) Sim-L (Dim+), and Sim-S (Dim+) groups in that order. Because the intensity of CS_2^+ was not a factor for the control condition, means are also presented in Table 3 in which separation on the basis of CS_2^+ is not made. For these comparisons the control group is highest in means of numbers of CRs followed by the sequential, simultaneous-long, and simultaneous-short groups.

The significant Stimuli effect of this analysis indicates that differential responding was generally present when the various experimental and control conditions were ignored, i.e., more responses were given in acquisition to the CS^+ than to the CS^- .

The significant F for the Conditions and Intensity of CS^+ x Stimuli interaction reflects the results of the seven acquisition conditions upon differential response rates. Multiple comparisons which were performed on various combinations of means within this interaction following Scheffe (1953) appear in Table 5. Comparisons were made both with and without consideration of CS_2^+

Table 5

Scheffe Comparisons on Means of Numbers of CRs in Acquisition

C	Group Means--CS+						d	d ²	Critical Value
	Sim-L (D+)	Sim-L (B+)	Sim-S (D+)	Sim-S (B+)	Seq (D+)	Seq (B+)			
23.389	19.933	28.600	14.200	20.367	25.067	25.233			
1.	+1	0	0	0	0	0	3.456	11.940*	11.211
2.	+1	-1	0	0	0	0	-5.211	27.157*	"
3.	+1	0	-1	0	0	0	9.189	84.434*	"
4.	+1	0	0	-1	0	0	3.022	9.134	"
5.	+1	0	0	0	-1	0	-1.678	2.815	"
6.	+1	0	0	0	0	-1	-1.845	3.402	"
7.	0	+1	0	0	0	0	-8.667	75.112*	8.408
8.	0	0	+1	-1	0	0	-6.166	38.027*	"
9.	0	0	0	0	+1	-1	-.167	.028	"
10.	+2	-1	0	0	0	0	-1.156	1.336	36.435
11.	+2	0	-1	-1	0	0	12.211	149.109*	"
12.	+2	0	0	0	-1	-1	-3.522	12.407	"
13.	0	+1	-1	-1	0	0	13.367	178.169*	16.816
14.	0	+1	0	0	-1	-1	-2.367	5.601	"
15.	0	0	+1	+1	-1	-1	-15.733	247.537*	"
Group Means--CS-									
20.056	10.067	11.967	8.667	12.300	23.167	9.700			
16.	+1	-1	0	0	0	0	10.029	100.579*	9.473
17.	+1	0	-1	0	0	0	8.089	65.430*	"
18.	+1	0	0	-1	0	0	11.389	129.707*	"
19.	+1	0	0	-1	0	0	7.756	60.148*	"
20.	+1	0	0	0	-1	0	-3.111	9.679*	"
21.	+1	0	0	0	0	-1	10.356	107.236*	"
22.	0	+1	-1	0	0	0	-1.900	3.610	7.105
23.	0	0	0	-1	0	0	-3.633	13.202*	"
24.	0	0	0	0	+1	-1	13.467	181.349*	"
25.	+2	-1	-1	0	0	0	18.078	326.807*	30.787
26.	+2	0	0	-1	0	0	19.144	366.508*	"
27.	+2	0	0	0	-1	-1	7.244	52.481*	"
28.	0	+1	+1	-1	0	0	1.067	1.138	14.209
29.	0	+1	0	0	-1	-1	-10.833	117.363*	"
30.	0	0	0	+1	-1	-1	-11.900	141.610*	"

intensity. An a priori significance level of .10 was utilized as suggested by Scheffe due to the conservative nature of this procedure. Method of computing significance levels for these comparisons appears in Appendix C.

The results of the Scheffe analysis indicate that both Group Sim-L and Group Seq were characterized by better differential responding than the control group. This superior differentiation was due to the greater suppression of responding to CS^- in these groups (lines 25, 27) as they did not differ significantly from Group C with regard to number of CRs to the CS^+ (lines 10, 12). Group Sim-S responded at a lower level to both positive and negative stimuli than Group C so that a definitive statement cannot be made regarding differential responding for this comparison (lines 11, 26).

Comparisons between experimental groups show Group Sim-L to be superior to Groups Sim-S and Seq in differential responding, due to a higher CS^+ response level than Group Sim-S and a greater response suppression to CS^- than Group Seq (Lines 13, 14, 18, 29). Group Seq was marked by a greater number of CRs to both CS^+ and CS^- than Group Sim-S so that relative differential responding between these two groups cannot be evaluated from this analysis (lines 15, 30).

If the experimental groups are further divided on the basis of CS_2^+ intensity into bright-positive (B+) and dim-positive (D+) groups, lowered response rates to the CS^- are found for all

experimental groups in control-experimental comparisons with the exception of Group Seq(D+) which did not differ from Group C (lines 16-21). For Groups Sim-L(D+), Sim-L(B+), Sim-S(B+) and Seq (B+) this is indicative of better differential responding as response levels to CS^+ were either not different from Group C (Groups Sim-L(D+), Sim-S(B+), and Seq(B+)) or were actually higher as with Group Sim-L(B+). Group Sim-S(D+) was characterized by lower performance to both CS^+ and CS^- than Group C so that a comparison regarding differential responding is not possible (lines 1-6).

Within each experimental condition, bright-positive groups differentiated better than their dim-positive counterparts, as a result of higher CS^+ response levels for Groups Sim-L(B+) and Sim-S(B+) and lower CS^- responding in the case of Group Seq(B+) (lines 13-15, 28-30).

The significant Conditions and Intensity of CS^+ x Stimuli x Trials interaction in Table 4 reflects the previously noted differences in the course of acquisition of differential responding under the various experimental- CS_2^+ Intensity conditions.

Part of the variance of the C-I x St x T interaction appears to be due to the late change in function of the CS^- curve for the control condition from positive to negative and the relative steepness of its downward trend once this change had occurred. As a result of this late suppression of CS^- response levels, differential responding is greatly improved for Group C during

the last block of 20 trials as shown in Figure 2 or during the last block of 10 trials appearing in Table 2. Experimental groups still appear superior to the control group in differential responding, but the superiority is greatly reduced for these trials. An analysis of variance was performed for trials 71-80 as summarized in Table 4 to determine if the discrepancies between control and experimental groups in differential responding were maintained at the close of acquisition. For this analysis Conditions and Intensity of CS^+ was a between S_s variable with Stimuli as a within S_s effect.

The significant F for Conditions and Intensity of CS^+ reflects differences between the seven groups in numbers of CRs in trials 71-80 summing across both positive and negative stimuli. Highest numbers of CRs were given by Group Seq(Dim+), followed by Control, Sim-L(Bright+), Sim-S(Bright+), Seq(Bright+), Sim-L(Dim+), and Sim-S(Dim+) groups, respectively. When CS_2^+ Intensity is ignored, the sequential group is highest with control, simultaneous-long, and simultaneous-short groups ranked in that order.

The significant Stimuli effect indicates that more CRs were given to the CS^+ than to the CS^- for trials 71-80 when experimental conditions and CS_2^+ intensity are disregarded.

The F for the Conditions and Intensity of $CS^+ \times$ Stimuli interaction was also significant, reflecting differences in

differential responding among the seven groups. However, in contrast to the results observed when all acquisition trials were considered, Scheffe comparisons appearing in Table 6 do not indicate superiority in differential responding for simultaneous-long and sequential groups over the control condition (lines 10-12, 25-27). The variance of this interaction is derived in part from the superior differential responding of bright-positive groups as compared with their dim-positive counterparts in the Sim-L and Seq conditions (lines 7, 22, 24).

First Test Trial.--Data from the first trial following acquisition were analyzed to observe the effects of temporal relationships between stimuli during training upon response levels to elements of the compounds prior to the extinction process. A frequency count of presence or absence of CRs serves as data for two analyses. In the first analysis, Ss receiving isolated presentation of CS_1^+ , CS_2^+ , CS_1^- , and CS_2^- are used to evaluate differential responding to elements of the stimulus compounds of acquisition. For this design, Experimental Group (Sim-L, Sim-S, Seq) is orthogonal to the Stimuli (CS^+ , CS^-) and CS Position (CS_1 , CS_2) effects. In the second analysis, Ss tested to elements of the CS^+ compound are compared with Ss receiving the intact CS^+ compound. This design has the three levels of Experimental Group orthogonal to CS^+ Condition (CS^+ , CS_1^+ , CS_2^+). That all groups

Scheffe Comparisons on Mean Numbers of CRs in Trials 71-80

C	Group Means--CS+						d	d ²	Critical Values
	Sim-L (D+)	Sim-L (B+)	Sim-S (D+)	Sim-S (B+)	Seq (D+)	Seq (B+)			
3.222	3.067	4.367	2.533	3.333	3.800	3.767			
1.	-1	0	0	0	0	0	.156	.024	2.026
2.	0	-1	0	0	0	0	-1.145	1.310	"
3.	0	0	-1	0	0	0	.689	.475	"
4.	0	0	0	-1	0	0	- .111	.012	"
5.	0	0	0	0	-1	0	- .578	.334	"
6.	0	0	0	0	0	-1	- .545	.296	"
7.	+1	-1	0	0	0	0	-1.300	1.690*	1.519
8.	0	0	+1	-1	0	0	- .800	.640	"
9.	0	0	0	0	+1	-1	.033	.001	"
10.	-1	-1	0	0	0	0	- .989	.978	6.584
11.	0	0	-1	-1	0	0	.578	.334	"
12.	0	0	0	0	-1	-1	-1.122	1.260	"
13.	+1	+1	-1	-1	0	0	1.567	2.455	3.039
14.	+1	+1	0	0	-1	-1	- .133	.018	"
15.	0	0	+1	+1	-1	-1	-1.700	2.890	"
Group Means--CS-									
2.167	1.233	.867	1.100	1.733	2.567	1.133			
16.	-1	0	0	0	0	0	.933	.866	2.016
17.	0	-1	0	0	0	0	1.300	1.690	"
18.	0	0	-1	0	0	0	1.067	1.138	"
19.	0	0	0	-1	0	0	.433	.188	"
20.	0	0	0	0	-1	0	- .400	.160	"
21.	0	0	0	0	0	-1	1.193	1.424	"
22.	+1	-1	0	0	0	0	1.790	3.207*	1.512
23.	0	0	+1	-1	0	0	- .633	.401	"
24.	0	0	0	0	+1	-1	1.433	2.055*	"
25.	-1	-1	0	0	0	0	2.233	4.988	6.552
26.	0	0	-1	-1	0	0	1.500	2.250	"
27.	0	0	0	0	-1	-1	1.633	2.668	"
28.	+1	+1	-1	-1	0	0	- .733	.538	3.024
29.	+1	+1	0	0	-1	-1	- .600	.360	"
30.	0	0	+1	+1	-1	-1	.133	.018	"

within each experimental condition did not differ at the start of test trials is verified by analysis of variance for trials 71-80, $F(8,165) = 1.04$, $p > .20$.

Table 7 shows the numbers of CRs for the experimental conditions when elements of the compounds were presented separately. Frequencies are presented with regard to whether the element is a CS_1 or CS_2 and within these categories a further classification is made on the basis of CS^+ and CS^- . Intensity of CS_2^+ was disregarded for these analyses due to the small theoretical frequencies which would have resulted from its inclusion. Summing across all elements, the simultaneous-short group appears to have given a greater number of CRs than Groups Sim-L and Seq. With regard to differential responding, discrepancies between CS^+ and CS^- appear to have lessened from acquisition levels as a function of element presentation. Group Sim-L appears to have suffered most from this separation procedure with no differential responding apparent for the CS_1 contrast. Differential responding was better for the CS_2 comparison in both simultaneous conditions, but the CS_1 contrast was superior for the sequential group.

Analysis of these data by means of a X^2 technique suggested by Sutcliffe (1957) is summarized in Table 7. The non-significant Experimental Group effect does not substantiate the observation that the groups differed with regard to total numbers of CRs. The nonsignificant Stimuli effect indicates that differential responding did not occur at the same high level

Table 7

Cell Frequencies and Sutcliffe X^2 Analysis of
Number of CRs to Elements on First Test Trial

Cell Frequencies

Condition (Experimental)	CS1				CS2				Total	
	CS ⁺		CS ⁻		CS ⁺		CS ⁻			
	CR	$\overline{\text{CR}}$	CR	$\overline{\text{CR}}$	CR	$\overline{\text{CR}}$	CR	$\overline{\text{CR}}$	CR	$\overline{\text{CR}}$
Sim-L	5	7	5	7	4	8	3	9	17	31
Sim-S	7	5	6	6	6	6	2	10	21	27
Seq	8	4	5	7	2	10	1	11	16	32
Total	20	16	16	20	12	24	6	30	54	90

Sutcliffe X^2 Analysis

Source	<u>df</u>	<u>X^2</u>
Total	11	18.13*
Experimental Group (G)	2	1.24
Stimuli (st)	1	2.96
Stimulus Position (P)	1	9.60**
G x St	2	.97
G x P	2	2.31
St x P	1	.12
G x St x P	2	.93

* $p < .10$

** $p < .01$

when elements were presented as during acquisition to the intact compounds. The significant Stimulus Position effect indicates that there were higher response levels to the CS₁s than to the CS₂s. All interactions were nonsignificant.

Response levels to elements of the positive stimulus compound are compared with responding to the intact CS⁺ compound in Table 8. In general, the separate presentations of the elements appear to have resulted in lower levels of responding with CS₂⁺ most affected. Group Sim-S appears to have suffered least from the separation procedure. In the case of Group Sim-L both CS₁⁺ and CS₂⁺ appear markedly lower than the intact CS⁺ group in numbers of CRs given. For the Seq condition only the CS₂⁺ group appears to have suffered greatly from this manipulation but the decrement is severe for this group.

Table 8 summarizes the X² analysis performed on these data. The nonsignificant Experimental Group finding suggests that Groups Sim-L, Sim-S and Seq did not differ in numbers of CRs when CS⁺ Condition is disregarded. The significant CS⁺ Condition effect substantiates the observation that element presentation resulted in decrements in response levels when compared to the intact CS⁺. The nonsignificant Experimental Group x CS⁺ Condition interaction does not verify the previously noted differential effects of experimental condition upon response levels to elements.

Table 8

Cell Frequencies and Sutcliffe X^2 Analysis of
Number of CRs on First Test Trial--CS⁺ Groups

Cell Frequencies

Condition (Experimental)	CS ⁺		CS ₁ ⁺		CS ₂ ⁺		Total	
	CR	CR	CR	CR	CR	CR	CR	CR
Sim-L	10	2	5	7	4	8	19	17
Sim-S	8	4	7	5	6	6	21	15
Seq	10	2	8	4	2	10	20	16
Total	28	8	20	16	12	24	60	48

Sutcliffe X^2 Analysis

Source	<u>df</u>	<u>X²</u>
Total	8	19.58*
Experimental Group (G)	2	.20
CS ⁺ Condition (C)	2	14.40**
G x C	4	4.97

* $p < .02$

** $p < .01$

Extinction.--Numbers of CRs per subject during each block of five extinction trials are used as data for three extinction analyses. In the first of these, the effects of acquisition conditions upon the process of extinction are observed using Ss extinguished to the intact CS^+ compounds. The second and third designs parallel analyses of the first test trial in which comparisons are made between intact positive compound and positive element responding and between elements with regard to differential responding.

Means and standard deviations for numbers of CRs in successive blocks of five extinction trials appear in Table 9. Considering only extinction with compounds, extinction was less rapid for conditions C and Seq than for conditions Sim-L and Sim-S. Extinction was rapid for all groups with percentages of CRs in trials 16-20 ranging only from 16 to 31 per cent. Table 10 summarizes the analysis of variance performed on these data. The only significant F for this analysis is for the Trials variable, indicating that experimental conditions had no effect on extinction.

In the comparison involving the combinations of Experimental Groups with CS^+ , CS_1^+ , and CS_2^+ , extinction appears to have been most rapid for the Seq- CS_2^+ combination and least rapid with the Seq- CS_1^+ combination. However, in the analysis of variance on these data (Table 11), the F for decrements over trials was the only significant effect.

Table 9

Means and Standard Deviations of Numbers of CRs during
Successive Blocks of Five Extinction Trials

Conditions	Stimulus		Trials				
			1-5	6-10	10-15	16-20	1-20
Control		M	2.39	1.22	1.33	1.22	6.16
		SD	2.13	2.53	2.00	1.48	
Sim-L	CS ⁺	M	1.83	.67	.50	.83	3.83
		SD	1.42	1.52	.82	1.97	
	CS ₁ ⁺	M	1.25	.66	.58	.58	3.07
		SD	1.48	.88	1.16	.99	
	CS ₁ ⁻	M	1.66	.91	.16	.25	2.98
		SD	1.61	.99	.38	.62	
	CS ₂ ⁺	M	1.25	1.16	.66	1.08	4.15
		SD	1.35	1.58	1.23	1.16	
	CS ₂ ⁻	M	.75	1.00	.75	.83	3.33
		SD	.75	1.12	.86	1.02	
Sim-S	CS ⁺	M	2.00	1.42	1.17	.83	5.42
		SD	3.45	2.63	3.24	1.24	
	CS ₁ ⁺	M	1.25	1.33	.58	.91	4.07
		SD	1.21	1.72	1.24	1.50	
	CS ₁ ⁻	M	1.25	.58	.66	.91	3.40
		SD	1.28	.79	.98	1.24	
	CS ₂ ⁺	M	1.58	.66	.66	.41	3.31
		SD	1.72	.98	1.23	.66	
	CS ₂ ⁻	M	.75	.50	.33	.50	2.08
		SD	.86	.79	.49	.52	
Seq	CS ⁺	M	2.17	1.83	1.58	1.58	7.16
		SD	2.15	3.79	3.17	1.90	
	CS ₁ ⁺	M	2.16	1.75	1.50	1.41	6.82
		SD	1.46	1.91	1.62	1.67	
	CS ₁ ⁻	M	.91	1.00	1.16	1.08	4.15
		SD	1.72	1.53	1.69	1.44	
	CS ₂ ⁺	M	.83	.50	.58	.33	2.24
		SD	1.19	.67	.66	.49	
	CS ₂ ⁻	M	.91	.83	.41	1.25	3.40
		SD	.79	1.02	.51	1.21	

Table 10
 Analysis of Variance on CRs given in Extinction
 by Intact CS⁺ Groups

Source	<u>df</u>	<u>MS</u>	<u>F</u>
Conditions (C)	3	6.04	1.03
Error (b)	50	5.86	
Trials (T)	3	12.10	12.45*
C x T	9	.61	<1
Error (w)	150	.97	

*p < .001

Table 11
 Analysis of Variance on CRs given in Extinction
 by Experimental-Positive Stimulus Groups

Source	<u>df</u>	<u>MS</u>	<u>F</u>
Experimental Group (G)	2	6.90	1.26
CS ⁺ Condition (C)	2	11.39	2.09
G x C	4	7.76	1.52
Error (b)	99	5.46	
Trials (T)	3	12.21	17.59*
G x T	6	.52	<1
C x T	6	.37	<1
G x C x T	12	.67	<1
Error (w)	297	.69	

*p < .001

Comparisons for Experimental Group-element combinations with regard to differential responding are also shown in Table 9. As noted on the first test trial, better differential responding for the simultaneous-long and simultaneous-short conditions appears with the $CS_2^+ - CS_2^-$ contrast than with the $CS_1^+ - CS_1^-$ comparison. The opposite trend is observed for the sequential condition. Analysis of variance on these data as summarized in Table 12, however, shows a significant F only for the Trials effects, reflecting the process of extinction.

Table 12
Analysis of Variance on CRs given by Element
Groups in Extinction

Source	<u>df</u>	<u>MS</u>	<u>F</u>
CS Position (P)	1	9.00	2.39
Experimental Group (G)	2	3.00	<1
Stimulus Positiveness (St)	1	4.69	1.24
P x G	2	8.54	2.27
P x St	1	1.56	<1
G x St	2	.18	<1
P x G x St	2	5.06	1.34
Error (b)	132	3.75	
Trials (T)	3	7.72	11.71*
P x T	3	.49	<1
G x T	6	.56	<1
St x T	3	.79	1.20
P x G x T	6	1.25	1.90
P x St x T	3	.74	1.13
G x St x T	6	.85	1.29
P x G x St x T	6	1.19	1.80
Error (w)	396	.65	

*p < .001

Discussion

Acquisition.--The finding that the sequential condition led to improved differential responding when compared to the control group is relevant to the primary objective of the present investigation. This result suggests that it is not necessary to postulate a long latency for inhibitory mechanisms in the treatment of long interval conditioning as postulated by Hartman and Grant. In all probability, a more complex type of conditioning occurs at longer CS-UCS intervals, but this investigation indicates that the added complexity over the short interval situation may actually consist of a longer chain of stimuli or stimulus-response units rather than a different type of conditioning process. With regard to differential conditioning, the superior differentiation observed at long CS-UCS intervals can then be regarded as a function of greater CS^+ and CS^- dissimilarity.

With regard to a secondary objective of this experiment, the factor of stimulus intensity was found significant with bright-positive groups differentiating better within each experimental condition. For Groups Sim-L and Sim-S this was due to a higher level of responding to CS^+ when the more intense stimulus was positive. This result utilizing a stimulus compound situation is in agreement with the findings of Moore (in press) in a study in which the intensity variable was manipulated with simple stimuli.

These results suggest some degree of generality for the Hullian concept of a "stimulus intensity dynamism" factor (V)

which is assumed to enter into a multiplicative relationship with the associative factor (H) of his system. Under conditions of differential conditioning one would expect the results of intensity manipulations to be most clearly discernible for the reinforced positive stimulus. An additive type of relationship would predict, of course, no such asymmetry with both positive and negative stimuli being equally affected by stimulus intensity. Group Seq did not follow the same pattern, however, with the bright-positive condition characterized by markedly lower response levels to the negative stimulus and CS^+ responding nearly equivalent across intensity conditions. The reasons for this deviation from expected results are not immediately clear.

The finding that Group Sim-L was superior to Group Sim-S in differential responding constitutes a partial replication and extension to stimulus compounds of the Hartman and Grant results with regard to CS-UCS intervals. Consistent with the latter, the 400 msec. interval group of the present investigation was characterized by lower CS^+ responding when compared with the 800 msec. group. The CS-UCS interval function of differential conditioning would therefore appear to differ somewhat from the interval function of simple classical conditioning with slightly longer intervals being optimal in the former.

In addition to the stated objectives, results of this investigation reveal that the introduction of distinctive relevant stimuli into the experimental situation is generally effective in

increasing the level of differential responding. The effectiveness of this procedure is, however, dependent upon maintaining the existing interval between the start of the CS or CS compound and the UCS as was the case with Groups Sim-L and Seq of this study. The findings are not as clear when the interval is shortened from the control condition as was the situation with Group Sim-S.

This procedure appears to be comparable to increasing the distinctiveness of single CS's by means of increasing the distance between positive and negative stimuli along some physical dimension. In agreement with results of this latter type of manipulation by Moore (in press), the gains in differential responding were due to lowered response levels to the negative stimuli. These findings are not in agreement with those of Gynther (1957) who found increased CS⁺ responding for a position-color discrimination group when compared with a position discrimination control. Gynther, however, used a shorter 500 msec. CS-UCS interval than the 800 msec. condition employed by Moore and in the present study and response rates for his control group were still rising markedly at the close of acquisition.

Within a Hull-Spence framework the results of this study would favor the 1963 schema presented by Spence (Spence & Tandler, 1963) in which differential responding is a function of conditioned habit to CS⁺, generalized habit to CS⁻, and inhibition accrued to CS⁻ as a function of nonreinforced trials. In this presentation

Spence does not assume that inhibition generalizes to CS^+ from CS^- so that, consistent with findings of the present investigation, response levels to the positive stimulus are independent of the similarity between stimuli. This type of result is partially predicted by the stimulus sampling models of Bush and Mosteller (1951) and Estes (1959) in which asymptotic levels of responding to CS^+ are independent of stimulus similarity. However, these models also predict a slower approach to asymptote under conditions of highly similar stimuli and this was not observed in the present study.

Of some interest is the finding that the introduction of distinctive stimuli was significantly related to improved differential responding when all trials were considered but not if the last block of trials was analyzed alone. The late change in function from positive to negative which occurred in the CS^- curve of the control group is responsible for this discrepancy. The ease of differential responding thus may not be reflected at asymptote if sufficient numbers of trials are utilized for a given set of experimental conditions, i. e., if training is continued beyond the point where the CS^- curve changes from a positive to a negative direction. Perhaps the more appropriate response measures lie in trials to some criterion or the point at which the CS^- function changes from positive to negative. Examination of acquisition data of Hartman and Grant (1962) and Spence and Tandler (1963) also suggest that the negative function of the CS^- curve is of possible relevance although this phenomenon has not yet received systematic

treatment in the classical conditioning literature.

Spence has tentatively treated inhibition as some positive function of excitatory potential to the positive stimulus (Spence, 1960; Spence & Tandler, 1963). In the case where differential responding would be most difficult, i. e., when positive and negative stimuli are highly similar, progressive increments in the habit strength of CS^- through generalization from CS^+ may be sufficient to counteract the decremental effects of inhibition due to nonreinforcement. Under these circumstances the CS^- function is positive until the CS^+ asymptote is reached. At this point where reinforcement no longer leads to significant increments in excitatory potential, however, CS^- responding should decrease regardless of the similarity of stimuli. In fact, the later the change in function of the CS^- from positive to negative the steeper should be the decrements. This is due to a) a lack of further generalized increments which would tend to neutralize the effects of increased inhibition and b) the assumption that increments in inhibition are greatest at the highest levels of excitatory potential. This prediction is consistent with data from the present investigation in which Group C was characterized by a late change in CS^- function with the negative course of the curve having a steeper downward trend than observed for Groups Sim-L and Seq once the change in function occurred.

Test-Extinction Trials.--Related to a secondary objective of the present investigation were the findings regarding the separate presentation of elements following acquisition. Although

all element groups were characterized by lessened differential responding, these manipulations had different effects upon the various experimental conditions. For Group Sim-L the separation procedure resulted in significant decrements in responding to both CS_1^+ and CS_2^+ elements when compared to a group receiving the intact CS^+ compound. In the sequential groups, however, CS_1^+ emerged as the dominant element with significantly greater response strength than the isolated CS_2^+ element. This finding occurred in spite of the fact that the CS_2 s were the distinctive stimuli in the situation, a factor which would intuitively make their dominance seem likely.

Also of some interest in this regard is the nonsignificant finding that differential responding on the basis of the CS_1 contrast was superior to the CS_2 comparison for Group Seq. The opposite result was obtained from the simultaneous groups, again statistically nonsignificant but consistent throughout extinction. Relevant to these findings is the observation by Wickens (1959) regarding simple conditioning to stimulus compounds that the initiating stimulus becomes dominant when the CS_1 - CS_2 interval is optimal for classical conditioning, i.e., in the neighborhood of 500 msec. It would appear on the basis of present findings that this principle can be extended to the differential conditioning situation with little or no modification.

Summary

Differential conditioning to stimulus compounds was investigated in the classically-conditioned eyelid response. A control group was given 80 differential conditioning trials to highly similar tones serving as CS^+ and CS^- . Three experimental groups were given comparable training to stimulus compounds. On any given trial these groups received stimulation provided by one of the previously mentioned tones and one of two distinctive light intensities presented either simultaneously at a long CS-UCS interval (Group Sim-L), simultaneously at a short interval (Group Sim-S), or sequentially with the light presentation following the tone onset by a short interval (Group Seq). Following acquisition trials, experimental groups were further divided into five groups each for test-extinction trials to the intact positive stimulus (CS^+) or to one of the isolated stimulus elements (CS_1^+ , CS_2^+ , CS_1^- , or CS_2^-). The control group received the positive stimulus in extinction.

Principle findings were as follows: 1) the sequential compound condition resulted in superior differential responding in acquisition when comparison was made with the control condition; 2) the simultaneous-long condition was superior in differentiation to the simultaneous-short condition; 3) both the simultaneous-long and sequential conditions resulted in better differential responding in acquisition than the control condition, due to lowered CS^- response levels rather than increased CS^+

responding; 4) differences between experimental and control conditions were no longer significant for the last block of 10 trials due to the relatively sudden increase in inhibition of CS^- responding late in the acquisition phase for the control group; 5) within each experimental group those Ss receiving the more intense light as part of the positive compound were superior in differential responding to their dim-positive counterparts, as a result of increased CS^+ responding for the simultaneous groups and as a function of suppression of CS^- levels for the sequential group; 6) the separate presentation of positive elements on the first test trial resulted in marked decrements for Groups Sim-L and Seq when element groups were compared with intact CS^+ groups, both elements moderately affected for the simultaneous condition and only CS_2^+ affected in Group Seq.

From the first of these results, the conclusion was made that it is not necessary to postulate separate CS-UCS interval functions for positive and negative response tendencies to explain the optimal 800 msec. CS-UCS interval previously observed in differential conditioning. The second finding constitutes a partial replication and extension to the stimulus compound situation of results obtained by Hartman and Grant (1962) on CS-UCS intervals in differential conditioning to simple CSs. The third and fourth results favor the differential conditioning

schemata of Spence and Tandler (1963) in which no generalization of inhibition is assumed and inhibition is presumed to be some positive function of response strength to the positive stimulus. The stimulus intensity result was regarded as supporting the Hullian concept of stimulus intensity dynamism as a multiplier of habit strength since the reinforced stimulus most clearly reflected the effects of intensity. The findings with regard to the separate presentation of elements were noted to be consistent with data by Wickens (1959) in simple conditioning to compound stimuli.

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Appendix A

Review of Theoretical Literature.--In simple classical conditioning, i.e., in experimental situations in which only a conditioned stimulus (CS) and unconditioned stimulus (UCS) are presented, the onset of the CS represents the only dynamic event in the experimental context other than the UCS. This situation can be analyzed in terms of a differentiation of trial from non-trial with the CS serving as the basis of the differentiation (Logan, 1954; Perkins, 1953). It can be questioned in such simple situations whether the conditioned response (CR) has been formed to the CS per se or to environmental change. This confounding of CS presentation with environmental change could thus be a factor in generalization experiments, perhaps most conspicuous in those instances in which generalization of response strength has been demonstrated to stimuli differing in modality from the CS.

The differential conditioning situation involves the presentation of two or more dynamic stimuli with reinforcement coincident with only one stimulus, the remainder either not followed by reinforcement or being reinforced under less optimal conditions than the positive stimulus. Differential conditioning, like simple conditioning, can be thought to involve the presence or absence of a CR based on the differentiation of trial from non-trial. However, in simple conditioning the non-trial is distinguished by a static stimulus situation, whereas in differential conditioning the non-trial involves both static and dynamic stimuli. This situation gains an added dimension approaching the extra-

laboratory situation in which environmental change is the rule rather than the exception with only a small percentage of the dynamic stimuli being "relevant" for the organism, i.e., followed by reinforcement. Under these experimental conditions, it has been observed that the subject responds appropriately within limitations, i.e., that he tends to respond to the reinforced stimulus (CS+) with greater frequency than to the non-reinforced stimulus (CS-). The latter, however, usually does acquire some capacity to evoke the conditioned response (e.g., Hartman & Grant, 1962).

Spence (Spence & Beecroft, 1954; Spence & Farber, 1954; Spence & Tandler, 1963) approaches the problem of differential conditioning by combining the effects of intervening variables within his system in the same manner as in the simple conditioning situation. The probability of response occurrence for a stimulus is a positive function of excitatory potential (E) which is in turn determined by generalized drive (D), directly conditioned habit (H), and generalized habit (\bar{H}). Thus, the excitatory potential of the CS+ (E+) is composed of the D factor combined in a multiplicative relationship with directly conditioned habit (H+), generalized habit from the CS- ($\bar{H}+$) being equal to zero since CS- does not receive reinforcement. Excitatory potential of CS- (E-) involves the multiplicative combination of the D variable and habit which has generalized to CS- from CS+ ($\bar{H}-$). Differential responding is then a function of the difference between E+ and E-, i.e.:

$$E+ - E- = D(H+) - D(\bar{H}-) = D(H+ - \bar{H}-)$$

Predictions from this array of intervening variables would consequently be 1) that high levels of drive lead to better differential responding than do low drive levels, 2) that high levels of drive lead to greater responding to both CS+ and CS- than do low levels, and 3) that a high degree of generalization between CS+ and CS- attenuates differential responding by leading to relatively high response strength for CS-.

When differential responding is optimal, response strength to the CS+ is at a high level, whereas a small percentage of responses are given to the CS-. The motivational variable in the Spence system enhances differential responding by means of raising response strength to the CS+. Two methods of increasing differential responding through suppression of CS- responding are possible in the general Hull-Spence approaches to the learning situation. The first of these is through lessened generalization of habit strength from CS+ to CS-. The second involves the concept of inhibition due to nonreinforcement (In). Thus far, this variable, which is defined as a function of the number of trials on which the CS is presented without reinforcement, has not received systematic treatment by Spence in the classical differential conditioning situation although it is included in the formal theoretical schema for classical defense conditioning (Spence, 1960). A speculation is offered in one study, however, that In contributes to the formula for differential responding as follows (Spence & Tandler, 1963):

if: $E+ = D \times H+$

and: $E- + D \times \bar{H}- = In-$

then: $E+ - E- = D(H+ - \bar{H}-) + In-$

In this formulation In is conceived of as positive functions of both the number of nonreinforced trials and the excitatory potential of $CS+$ ($E+$). Furthermore, the implicit assumption is also made that $E+$ is not influenced by generalization of inhibition accrued to $E-$. This is in contrast to the assumptions of generalized inhibition which appear in Spence's treatment of discrimination learning and transposition in instrumental reward conditioning (Spence, 1960) and the model of differential conditioning derivable from Hull's system (Hull, 1943). This type of formulation is seen below:

$$E+ - E- = D(H+ - \bar{H}-) + (In- - \bar{In}+)$$

A "conditioning-extinction" approach (Kimble, 1961) such as the above would suggest that $CS+$ responding is not independent of inhibitory factors built up to $CS-$. A verified prediction of this formula is that the introduction of inhibition by means of a $CS-$ following reinforced trials to a $CS+$ leads to some suppression of responding to the $CS+$ (Gynther, 1957).

As previously noted, another means by which differential conditioning can be enhanced is through attenuation of generalization between stimuli. In the formulation which ignores inhibition, this would have its effect by lessening the response strength of the $CS-$, whereas in the Hullian or extended Spence system an additional aid to differential responding would involve the increasing of excitatory potential of the $CS+$ through less

generalized inhibition. Generalization factors can be altered in this situation either through the direct means of manipulating the physical similarity of the stimuli (e.g., Moore, 1962) or through mediational responses which contribute distinctive stimuli to resultant stimulus compounds of CS+ and CS-.

Dollard and Miller (1950) developed a paradigm of acquired distinctiveness based on these mediational or "cue-producing" responses. Essentially, mediated distinctiveness as originally developed regarding human subjects involves the use of verbal labeling responses which are made to external stimuli. These responses are assumed to produce stimuli which have previously been conditioned to distinctive responses in a discrimination problem or to the opposing tendencies of excitation and inhibition in the differential conditioning situation. Assuming some degree of generalization between the external stimuli, differential conditioning to these stimuli alone will be hampered by the generalized response strength accrued to the negative stimulus from the positive and generalized inhibition from the negative to the positive. The situation is altered, however, by the introduction of highly distinctive response-produced stimuli which become elements of stimulus compounds. Assuming 1) that response-produced stimuli contribute significantly to the habit strength of the compound and 2) that there is insignificant generalization between these response-produced stimuli, it follows that differential responding in the mediated distinctiveness situation is enhanced due to the lessened similarity of the stimulus compounds serving as CS+ and CS-. Conversely, in an acquired equivalence

paradigm in which the external stimuli are highly dissimilar and the response-produced stimuli are the same or highly similar, one would expect differential responding to be attenuated due to increased similarity of the stimulus compounds.

Hartman and Grant (1962), in demonstrating that optimal CS-UCS intervals are longer for differential responding than for simple conditioning, suggest that the process of inhibition is of longer latency than are the positive response tendencies customarily observed at short CS-UCS intervals. This leads to the postulation of two forms of classical conditioning, one a simple process involving "basic response tendencies" at short CS-UCS intervals and the second a more complex phenomenon characterized by additional inhibitory principles. Since in the Hartman and Grant study conditions for nonreinforced trials were constant across the various CS-UCS intervals, the seeming paradox is presented that the course of responding to CS- is determined by the events which are coincident with CS+. This becomes less confusing, however, in the light of findings that the latency of the eyelid CR covaries with CS-UCS intervals (Boneau, 1958; Prokasy, Ebel, & Thompson, 1963). From this it follows that longer inter-stimulus intervals would have their influence on response strength to CS- by means of delaying the response so that inhibitory mechanisms could be activated prior to the expected CR latency. Thus, at short intervals, long-latency inhibitory factors would not affect CRs which were given rapidly to CS- due to generalization from CS+. Response tendencies of a greater latency, however, would be subject to the influence of inhibitory processes.

The details and implications of this approach are not clearly detailed by Hartman and Grant beyond noting that it overlaps in explanatory power with "mediating perceptual response" notions in their CS-UCS interval findings. It is clear, however, that the usual explanations regarding the decremental effects of partial reinforcement and extinction which hinge about inhibition due to non-reinforcement are inadequate in the case of the short latency CR if a "two process" conception is held.

Review of Empirical Literature.--Hilgard, Campbell, and Sears (1937; 1938) conducted an early series of differential eyelid conditioning experiments in which the effects of CS-UCS intervals and insight into the nature of differential conditioning were investigated. Increases in illumination of two windows separated by 2.5 cm on a horizontal plane served as CS+ and CS- in all studies. In one investigation CS-UCS intervals were varied with the result that best differential responding occurred at the longer intervals. It was observed that, when differential responding was nonoptimal, a high level of responding to CS- was more frequently involved than a suppression of responses to CS+. It was also noted that the latency of the CR tended to covary with the inter-stimulus interval and with the level of differential responding.

In a second experiment subjects were instructed to report on the events of each preceding trial during the intertrial interval. This procedure did not markedly facilitate differential conditioning when results were compared with the first experiment although the authors reported a positive relationship between differential responding and the quickness with which insight into the proceedings

was reported. From this it was hypothesized that subjects in the first experiment were verbalizing silently in a manner similar to the subjects of the second experiment. In the third experiment subjects were given 60 reinforced trials to the CS+ followed by 60 differential conditioning trials. Prior to the differential conditioning trials, one group of subjects was given insight into the procedure which was to follow. For the first 12 trials this group was characterized by better differential responding than the control group but the differences between groups had largely disappeared by trials 25 and 36. It was postulated that subjects in the control group had verbalized to themselves the nature of the experiment as conditioning progressed. A series of extinction trials were also given with the result that the successful discriminators tended to extinguish more rapidly than nondiscriminators.

Hilgard, Jones, and Kaplan (1951) separated subjects on the basis of Manifest Anxiety Scale (MAS) performance and gave 60 reinforced trials to CS+ followed by 60 differential conditioning trials to the stimuli employed by Hilgard, Campbell, and Sears. Contrary to Hull-Spence predictions that higher motivational states lead to greater differential responding, the authors report a significant correlation of .37 between lack of discrimination and anxiety. A X^2 analysis also revealed that a significantly large proportion of high anxious subjects were classified as poor differential responders. The authors conclude that the highly anxious subjects were reacting more to their own apprehensions than to carefully discriminated environmental objects and relationships.

Data from several Iowa investigations on the effects of drive level in differential conditioning support the Hull-Spence systems (Runquist, Spence, & Stubbs, 1958; Spence, & Beecroft, 1954; Spence & Farber, 1954). Spence and Farber separated subjects into high and low anxious groups on the basis of MAS scores and conducted two experiments, one in which the UCS was omitted on trials to CS- and a second in which the UCS was presented at a 2500 msec. interval on nonreinforced trials. Stimuli were tones of 500 and 5000 cps presented in 100 differential conditioning trials. In both experiments high anxious subjects gave significantly more responses to CS+ than did the low anxious group and were superior in differential responding, the latter finding not reaching statistical significance.

Spence and Beecroft (1954) utilized the same stimuli as Spence and Farber and divided subjects into high and low anxious groups for a conditioning procedure which involved 50 reinforced trials to CS+ followed by 50 differential conditioning trials. As in the Spence and Farber study, high anxious subjects responded at a higher level to CS+ and were superior to low anxious subjects in differential responding with the latter finding again not significant.

Runquist, Spence, and Stubbs (1958) investigated the effects of drive upon differential responding by means of differing intensities of the UCS. Using tones of 500 and 5000 cps as stimuli, high and low drive groups were trained with UCS intensities of 2 and .3 psi, respectively, in 60 randomly alternated trials to CS+ and CS-. Findings of this study were consistent with the previous investigations of Spence et. al. when all subjects were utilized. In addition, when the lowest third of the subjects were removed from each group,

the predicted difference for differential responding between high and low drive groups reached significance.

Results from the investigations on motivation in differential conditioning are thus in conflict, three studies indicating that high drive aids differential responding and one that indicates attenuation of differentiation with high activation. Hartman and Grant (1962) suggest that the differing results of these studies might be explained by a two-system interpretation since Spence et. al. investigations involved CS-UCS intervals of 490-500 msec. and Hilgard, Kaplan, and Jones employed a 650 msec. interval. According to this view, the studies finding that high motivational levels potentiated differential responding would involve a simple type of conditioning, whereas the Hilgard et. al. experiment involved additional inhibitory principles.

Gynther (1957) tested several predictions derivable from the Hull-Spence systems. Subjects were trained to two lights laterally separated by two inches with a CS-UCS interval of 500 msec. It was found that differential conditioning suppressed the level of responding to CS+ when a comparison was made with a group which received a simple conditioning procedure. Also, the introduction of nonreinforced trials to a CS- following simple conditioning led to immediate decrements in responding to CS+ which partially disappeared with further training. Increasing the differences between stimuli by adding color and intensity dimensions led to better differential responding and to a higher level of responding to CS+. Utilizing a CS+ to CS- ratio of 3:1 instead of the usual 1:1 ratio resulted in a higher level of responding to both stimuli and to no

increases in level of differential responding. When a partial reinforcement schedule was used for CS+, subjects were unable to respond differentially. These results were interpreted as supporting a "conditioning-extinction" approach to differential conditioning involving generalization of response strength and inhibition.

Spence and Tandler (1963) investigated the effects of increasing the strength of the habit or associative factor (H) upon differential conditioning. Taking note of previous findings that the intensity of the reinforcing UCS acts upon the H factor in Spence's system, the authors trained one group of subjects by pairing CS+ with an air puff of 2 psi at a 500 msec. interstimulus interval and CS- with a .33 psi puff at a nonoptimal 2500 msec. interval. Intensities of the UCS were reversed for a weak reinforcement group. Consistent with predictions of the Spence system, strong reinforcement under these conditions of equated drive led to higher levels of responding to both CS+ and CS- and also resulted in better differential responding.

Moore (in press) conducted two experiments in which stimulus similarity and intensity were investigated. In the first study, tones serving as stimuli were separated by 0, 50, 100, 200, and 400 cps and presented at 60 or 85 db. Under these conditions, it was found that increasing differences between stimuli aided differential responding by raising the level of responding to CS+ and suppressing CS- responding. Also, CS+ responding was elevated when stimuli of 85 db were employed. In the second experiment groups were trained to respond differentially to a tone of 1000 cps with intensity levels of 60-85, 60-74, and 74-85 db with CS+ being the more intense stimulus

for half of the subjects within each of these three groups. Increased differential responding due to higher levels of responding to CS+ were observed when CS+ was the more intense stimulus. The results with regard to stimulus similarity were interpreted as supporting the Hull system and stimulus sampling theories of discrimination learning. The effects of stimulus intensity conformed with Hull's notions of stimulus intensity dynamism combining in a multiplicative manner with associative factors (Hull, 1951).

Attempts at demonstrating the effects of mediating responses in differential conditioning have not always been successful in spite of the explanatory value of the mediation paradigm in more complex learning situations. Grice et. al. (Grice & Davis, 1958; 1960; Grice, Simmons, & Hunter, 1963) have conducted a series of investigations utilizing an acquired equivalence paradigm in which one of two negative stimuli is trained to the same mediating response as the positive stimulus. Grice and David presented a tone of 850 cps as the CS+ with 240 and 1900 cps tones serving as non-reinforced stimuli. Subjects were instructed to make one of two manual responses at the onset of each stimulus with the CS+ and one of the negative stimuli having a common response. Evidence was gained for increased response strength to the CS- which shared the manual response with the CS+. However, reaction time measures for the manual responses revealed that the completed responses could not have served as mediating responses since their occurrences coincided and frequently surpassed the onset of the UCS. Also, a general facilitative effect from these responses was noted.

The subsequent series of studies by Grice, Simmons, and Hunter

dealt with implicit manual and verbal mediating responses and overt verbal responses which preceeded the UCS by 1200-1300 msec. Under these conditions no effects of mediated equivalence were noted. The authors comment that the results obtained are not consistent with existing mediation theory, i.e., that mediational effects were noted only when an overt response was given in close temporal proximity to the UCS.

Hartman (1963) investigated semantic transfer factors in a differential eyelid conditioning situation. Subjects were initially given differential training to one of three word pairs: right-left, pink-blue, or lion-deer. Following 40 such trials, a second phase of 40 differential conditioning trials were given to laterally separated lights of pink and blue which became stimulus compounds of left-blue, right-pink, etc. Subjects were instructed to make the overt verbal responses of left and right or pink and blue to these stimuli.

Under these circumstances, marked facilitation of differential responding early in the second phase was apparent whether the initial training words were irrelevant to, relevant to, or the same as the words verbalized during the second phase. There was greater transfer observed when the initial training had been carried out with the same words which were repeated in the second task and when relevant words were repeated. Sameness of the verbal stimuli from task to task did not produce significantly greater differential responding than relevance of task one stimuli although means were ordered in that direction. From the latter finding, the author concluded that the data provides no explicit support for mediated transfer based on

subvocal responses to the initial words. Also, although subjects with longer CR latencies displayed better differential responding, latencies of the mediating responses were on the average too long to be considered as part of the effective stimulus complex and did not significantly correlate with differential responding. These latency findings, along with the complex stimulus situations in which both overt and implicit responses were present, make the significance of this study for mediation theory somewhat dubious.

Wickens et. al. (Wickens, 1959; Wickens & Gross, 1959; Wickens, Gehman, & Sullivan, 1959) have conducted a series of simple conditioning experiments utilizing stimulus compounds which have relevance to the acquired distinctiveness approach to CS-UCS intervals in differential conditioning. These investigations with the conditioned GSR have involved two conditioned stimuli presented sequentially prior to a shock serving as the UCS. The paradigm of CS₁ followed by CS₂ which is followed by the UCS is the same as that of the mediating response paradigm except that the CS₂ is experimenter-produced rather than the result of a verbal or motor response which the subject makes in the CS-UCS interval.

In the situation in which CS₁ preceeded the onset of CS₂, the optimal CS₁-UCS intervals were found to be in the range of 900-1000 msec. (Wickens, Gehman, & Sullivan, 1959). These intervals were of greater magnitude than the optimal 500 msec. interval obtained for a group given acquisition trials with a single stimulus. The inter-stimulus interval function in the stimulus compound situation did, however, coincide with the typical single CS-UCS function if the onset of the CS₂ was utilized as the point of reference rather than the onset of the UCS. Since the CS₂-UCS intervals were a constant

500 msec., the 1000 msec. CS₁-UCS interval was characterized at the same time by a CS₁-CS₂ interval of 500 msec. Wickens (1959) thus concludes that, with regard to temporal relationships between stimuli, stimulus compounds in a sequential arrangement follow the same laws as do simple stimuli.

An extrapolation of these findings into a mediated distinctiveness paradigm would lead to the prediction that differential conditioning would be optimal when the interval between stimuli is sufficient to allow for CS+ and CS- to be conditioned to mediating responses which would lend distinctiveness to the subsequent stimulus compounds of CS and a response-produced stimulus. This optimal CS-UCS interval would be in the range of 800-1000 msec. based on previous data from single-stimulus, simple conditioning investigations and the work of Wickens et al.

Hartman and Grant (1962) investigated the temporal relations between the CS and UCS, utilizing groups trained to laterally separated lights at CS-UCS intervals of 400, 600, 800, and 1000 msec. Subjects were given 88 differential conditioning trials with the UCS omitted on nonreinforced trials. An 800 msec. CS-UCS interval was found to be optimal for differential responding. This is in contrast to the shorter intervals demonstrated as optimal in the simple eyelid conditioning situation (e.g., Kimble, 1947; McAllister, 1953). At a CS-UCS interval of 600 msec., Hartman and Grant found that differential responding was nonoptimal due to a lack of inhibition of responses to the CS- as CS+ responding was at a high level. At 1000 msec., the relatively poorer level of differential responding was attributable to a moderately low level of response strength to the CS+, responses to the CS- being effectively inhibited.

In spite of the congruence between the predictions derivable from the data of Wickens et. al. and the optimal 800 msec. interval observed, Hartman and Grant do not favor a mediating response interpretation of their findings. They note that the group trained with a 600 msec. CS-UCS interval was characterized by the highest asymptotic response level to the CS+, suggesting that the relatively long optimal interval seen in differential conditioning is related primarily to the inhibition of responses to the CS-. They speculate, therefore, that inhibition of responding may simply require more time due to some additional mechanism which cannot act at the shorter CS-UCS intervals.

Appendix B

Instructions

First, I am going to adjust the apparatus and then I will tell you more about the experiment.

In this experiment we are interested in the manner in which your eye responds to various types of stimulation. The stimulation will be provided by two tones, two lights, and a puff of air, all of which will be presented from time to time. The lights will be presented through the disk on the wall in front of you and the tones will come from a speaker situated behind you. The air puff is delivered by means of the nozzle attached to your headset.

The most important thing for you to do is to keep relaxed and comfortable and let the reactions of your eye take care of themselves. Just keep yourself oriented toward the disk in front of you and feel free to think about other things like work you have to do or anything else you might want to think about.

Scheffe Comparisons on CRs in Acquisition and Trials 71-80

This procedure by Scheffe (1953) is utilized to keep the error rate of the statistical analyses constant without restriction on the number of comparisons between means. The basic ratio is distributed as t , i.e.:

$$t = d_i / s_{d_i}$$

where: d_i = difference between any two means

s_{d_i} = standard deviation of difference

$$= \sqrt{s^2 \sum_{j=1}^k (a_{ji}^2 / n_j)}$$

and: a_{ji} = coefficient assigned to the j th mean in the i th comparison

n_j = number of subjects in the j th mean

$$s^2 = MS_E$$

$$= d_i / \sqrt{MS_E \sum_{j=1}^k (a_{ji}^2 / n_j)}$$

$$F = d_i^2 / MS_E \sum_{j=1}^k (a_{ji}^2 / n_j)$$

For significance tests, an adjusted F value is used:

$$F \geq F' = \left[d_i^2 / MS_E \sum_{j=1}^k (a_{ji}^2 / n_j) \right] \geq F' \quad \text{where: } F' = (k-1)F$$

$$= d_i^2 \geq F' MS_E \sum_{j=1}^k (a_{ji}^2 / n_j)$$

The Scheffe tables are of the preceding form where the coefficients (+1, -1, +2, 0) for each contrast lie in the grid under the means and d^2 is obtained by summing the coefficient-mean products in any given row and squaring the sum. Critical values have been computed using the formula:

$$6F_{(7,120)} MS_E \sum_{j=1}^k (a_{ji}^2 / n_j).$$

Appendix D

Analysis of Variance on CRs in Acquisition and
Trials 71-80--Nonvoluntary Subjects

Source	<u>df</u>	<u>Acquisition</u>		<u>Trials 71-80</u>	
		<u>MS</u>	<u>F</u>	<u>MS</u>	<u>F</u>
Conditions and Intensity of CS+ (C-I)	6	94.22	5.58**	7.92	2.80*
Error (b)	153	16.89		2.83	
Stimuli (St)	1	771.10	201.53**	279.38	243.78**
Trials (T)	7	41.32	29.98**		
St x T	7	29.19	38.15**		
C-I x St	6	43.82	11.45**	7.63	6.66*
C-I x T	42	1.05	<1		
C-I x St x T	42	1.30	1.69		
<u>Ss</u> x St/C-I	153	3.83		1.15	
<u>Ss</u> x T/C-I	1071	1.38			
<u>Ss</u> x StxT/C-I	1071	.77			

* p < .05

** p < .01

*** p < .001

Scheffe Comparisons on CBs in Acquisition--Nonvoluntary Subjects

C	Group Means--CS+						Seq (B+)	Seq (D+)	Seq (B+)	d	d ²	Critical Value
	Sim-L (D+)	Sim-L (B+)	Sim-S (D+)	Sim-S (B+)	Sim-S (D+)	Sim-S (B+)						
21.938	17.917	27.5416	13.875	19.250	22.708	25.625						
1.	+1	-1	0	0	0	0	0	0	4.021	16.168	25.449	
2.	+1	0	-1	0	0	0	0	0	-5.6041	31.4059*	"	
3.	+1	0	0	-1	0	0	0	0	8.0625	65.0039*	"	
4.	+1	0	0	0	0	0	0	0	2.6875	7.223	"	
5.	+1	0	0	0	0	0	0	0	-.771	.5941	"	
6.	+1	0	0	0	0	0	-1	-1	-3.6525	13.333	"	
7.	0	+1	-1	0	0	0	0	0	-9.625	92.641*	20.359	
8.	0	0	0	+1	-1	0	0	0	-5.375	28.891*	"	
9.	0	0	0	0	0	+1	-1	-1	-2.917	8.507	"	
10.	+2	-1	0	0	0	0	0	0	-1.583	2.507	71.257	
11.	+2	0	-1	-1	0	0	0	0	10.750	115.663*	"	
12.	+2	0	0	0	-1	0	-1	-1	-4.446	19.765	"	
13.	0	+1	-1	-1	0	0	0	0	12.333	152.108*	40.718	
14.	0	+1	+1	0	-1	0	-1	-1	-2.875	8.266	"	
15.	0	0	+1	+1	-1	-1	-1	-1	-15.208	271.126*	"	
Group Means--CS-												
19.063	9.083	12.1250	7.958	10.333	21.000	9.792						
16.	+1	-1	0	0	0	0	0	0	9.979	99.584*	14.864	
17.	+1	0	-1	0	0	0	0	0	6.9375	48.129*	"	
18.	+1	0	0	-1	0	0	0	0	11.104	123.303*	"	
19.	+1	0	0	0	-1	0	0	0	8.729	76.199*	"	
20.	+1	0	0	0	0	-1	0	0	-1.938	3.754	"	
21.	+1	0	0	0	0	0	-1	-1	9.271	76.679*	"	
22.	0	+1	-1	0	0	0	0	0	-3.042	9.252	11.891	
23.	0	0	0	+1	-1	0	0	0	-2.375	5.641	"	
24.	0	0	0	0	0	+1	-1	-1	11.208	125.628*	"	
25.	+2	-1	-1	0	0	0	0	0	16.917	286.175*	41.618	
26.	+2	0	0	-1	-1	0	0	0	19.833	393.364*	"	
27.	+2	0	0	0	0	-1	-1	-1	7.333	53.779*	"	
28.	0	+1	+1	-1	-1	0	0	0	2.917	8.507	23.782	
29.	0	+1	+1	0	-1	-1	-1	-1	-9.583	91.840*	"	
30.	0	0	0	+1	-1	-1	-1	-1	-12.500	156.250*	"	

*p < .10

C	Group Means--CS+					Seq (B+)	Seq (D+)	Seq (B+)	d	d ²	Critical Values
	Sim-L (D+)	Sim-L (B+)	Sim-S (D+)	Sim-S (B+)	Sim-S (B+)						
3.188	2.750	4.028	2.375	3.250	3.500	3.708					
1.	-1	0	0	0	0	0	.4375	.1914	2.319		
2.	0	-1	0	0	0	0	-1.021	1.042	"		
3.	0	0	-1	0	0	0	.813	.660	"		
4.	0	0	0	-1	0	0	-.063	.004	"		
5.	0	0	0	0	-1	0	-.313	.098	"		
6.	0	0	0	0	0	-1	-.521	.271	"		
7.	+1	-1	0	0	0	0	-1.458	2.127*	1.856		
8.	0	0	+1	-1	0	0	-.875	.766	.766		
9.	0	0	0	0	+1	-1	-.208	.043	"		
10.	-1	-1	0	0	0	0	-.583	.292	6.495		
11.	0	0	-1	-1	0	0	.750	.563	"		
12.	0	0	0	0	-1	-1	-.833	.694	"		
13.	+1	+1	-1	-1	0	0	1.333	1.778	3.711		
14.	+1	+1	0	0	-1	-1	-.250	.063	"		
15.	0	0	+1	+1	-1	-1	-1.583	2.507	"		
Group Means--CS-											
2.000	1.208	.958	1.042	1.500	2.375	1.042					
16.	-1	0	0	0	0	0	.7917	.627	2.204		
17.	0	-1	0	0	0	0	1.042	1.085	"		
18.	0	0	-1	0	0	0	.958	.918	"		
19.	0	0	0	-1	0	0	.500	.250	"		
20.	0	0	0	0	-1	0	-.375	.141	"		
21.	0	0	0	0	0	-1	.958	.918	"		
22.	+1	-1	0	0	0	0	.250	.063	1.763		
23.	0	0	+1	-1	0	0	-.459	.203	"		
24.	0	0	0	0	+1	-1	1.264	1.598	"		
25.	-1	-1	0	0	0	0	1.833	3.361	6.171		
26.	0	0	-1	-1	0	0	1.458	2.127	"		
27.	0	0	0	0	-1	-1	.583	.340	"		
28.	+1	+1	-1	-1	0	0	-.375	.140	3.526		
29.	+1	+1	0	0	-1	-1	-1.250	1.563	"		
30.	0	0	+1	+1	-1	-1	-.875	.766	"		

Acquisition Data

Subject	Stimulus	Block of Ten Trials							
		1	2	3	4	5	6	7	8
Group C									
1.	CS+	1	0	0	2	0	0	1	1
	CS-	0	1	0	1	0	0	1	0
2.	CS+	0	5	5	5	5	5	5	5
	CS-	1	1	0	2	3	4	0	1
3.	CS+	4	4	5	4	3	4	4	5
	CS-	5	5	5	4	4	5	4	4
4.	CS+	4	5	3	3	5	4	5	3
	CS-	3	5	0	4	2	4	0	2
5.	CS+	0	0	3	3	4	5	5	4
	CS-	1	1	2	1	2	2	0	0
6.	CS+	0	3	4	4	3	2	5	4
	CS-	3	4	5	5	4	4	5	3
7.	CS+	0	0	0	1	1	2	3	0
	CS-	1	0	1	0	2	2	2	1
8.	CS+	5	5	5	4	5	5	5	4
	CS-	5	5	5	5	5	5	5	3
9.	CS+	3	3	2	5	1	3	2	3
	CS-	5	2	2	3	2	1	4	1
10.	CS+	1	0	1	3	1	2	2	4
	CS-	1	1	3	2	3	3	1	5
11.	CS+	2	2	2	3	5	4	1	3
	CS-	1	3	3	4	3	3	3	0
12.	CS+	3	3	0	3	5	4	4	5
	CS-	4	3	3	4	4	4	1	5
13.	CS+	1	0	1	2	1	0	1	0
	CS-	2	0	1	0	0	0	2	0
14.	CS+	0	3	4	4	0	2	2	2
	CS-	1	3	0	1	0	0	1	0
15.	CS+	4	5	5	5	4	5	5	5
	CS-	4	3	3	4	4	4	5	5
16.	CS+	4	3	2	3	2	2	2	3
	CS-	4	3	2	2	3	3	1	2
17.	CS+	4	5	5	5	5	5	5	4
	CS-	5	5	5	5	4	4	3	5
18.	CS+	0	2	2	3	4	1	2	3
	CS-	3	1	1	3	1	3	1	2

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Sim-L; Dim+									
1.	CS+	1	1	0	2	2	5	4	4
	CS-	0	0	0	3	1	1	2	1
2.	CS+	0	1	1	3	3	3	3	4
	CS-	0	1	0	0	0	0	0	0
3.	CS+	2	3	3	2	4	4	0	4
	CS-	2	1	1	0	0	1	0	3
4.	CS+	0	2	3	4	4	3	4	5
	CS-	3	1	2	2	2	2	3	1
5.	CS+	3	5	5	5	5	5	5	5
	CS-	1	0	1	1	0	0	0	0
6.	CS+	2	3	4	4	5	4	5	5
	CS-	3	4	1	1	0	1	0	1
7.	CS+	0	0	1	1	3	2	3	4
	CS-	0	0	0	2	2	2	2	1
8.	CS+	3	5	5	5	5	5	4	5
	CS-	5	4	4	4	2	2	5	5
9.	CS+	4	3	5	4	5	5	4	4
	CS-	3	5	0	0	1	0	2	0
10.	CS+	0	2	3	4	4	5	5	5
	CS-	0	1	2	2	1	0	1	1
11.	CS+	2	3	4	5	5	5	5	5
	CS-	2	3	3	4	1	2	0	1
12.	CS+	0	0	1	2	3	3	5	3
	CS-	0	0	2	1	3	0	0	0
13.	CS+	0	0	0	0	1	0	0	1
	CS-	0	0	0	0	0	0	1	1
14.	CS+	0	0	0	0	0	0	0	0
	CS-	0	0	1	0	0	0	0	0
15.	CS+	1	0	2	0	1	0	0	0
	CS-	0	0	0	0	0	0	0	0

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Sim-L; Dim+ (Continued)									
16.	CS+	0	0	0	0	1	0	1	2
	CS-	0	0	0	0	0	0	0	0
17.	CS+	0	0	1	2	3	2	4	1
	CS-	1	0	1	0	1	1	2	2
18.	CS+	0	1	0	4	4	4	4	3
	CS-	0	1	3	4	5	5	3	4
19.	CS+	1	0	0	1	1	1	2	4
	CS-	0	0	0	1	3	2	3	3
20.	CS+	0	2	1	3	3	4	5	4
	CS-	0	0	1	0	0	0	1	0
21.	CS+	3	3	5	4	3	3	5	3
	CS-	5	5	5	1	3	5	5	2
22.	CS+	1	2	1	0	0	4	3	1
	CS-	0	1	1	0	1	0	2	1
23.	CS+	0	3	4	4	5	3	4	4
	CS-	0	0	0	1	0	1	0	2
24.	CS+	4	4	4	5	5	5	5	4
	CS-	4	5	5	5	4	5	5	2
25.	CS+	1	2	2	3	2	2	3	2
	CS-	3	0	0	0	0	0	0	0
26.	CS+	0	0	3	3	2	4	2	2
	CS-	0	0	1	1	0	0	0	0
27.	CS+	0	3	1	0	2	5	4	4
	CS-	0	1	1	0	1	0	0	1
28.	CS+	2	2	1	4	2	3	1	0
	CS-	3	1	0	0	0	1	1	0
29.	CS+	1	0	1	0	2	0	2	1
	CS-	0	0	0	1	1	0	0	0
30.	CS+	0	5	3	3	4	5	4	3
	CS-	2	4	4	4	4	4	4	5

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Sim-L; Bright+									
1.	CS+	4	5	4	5	5	5	5	5
	CS-	3	1	0	1	0	2	1	0
2.	CS+	1	5	5	5	5	5	5	5
	CS-	3	3	3	2	2	0	2	1
3.	CS+	1	4	4	4	5	5	3	5
	CS-	0	3	2	3	2	4	2	1
4.	CS+	0	0	1	4	3	2	2	2
	CS-	0	0	1	0	1	0	2	0
5.	CS+	3	1	1	3	2	4	2	4
	CS-	2	1	0	2	1	1	3	1
6.	CS+	2	3	4	4	5	5	4	5
	CS-	1	1	0	0	0	0	0	1
7.	CS+	2	4	2	5	4	4	5	5
	CS-	1	2	2	2	4	3	1	3
8.	CS+	2	2	4	2	3	1	3	1
	CS-	4	1	4	0	2	1	1	0
9.	CS+	0	3	5	5	5	5	5	5
	CS-	2	4	5	2	2	3	1	3
10.	CS+	1	5	5	5	5	5	5	5
	CS-	0	0	1	1	0	1	2	1
11.	CS+	0	4	4	5	5	5	5	5
	CS-	1	3	2	2	2	2	0	1
12.	CS+	3	5	5	5	5	5	5	5
	CS-	2	3	0	1	0	0	1	1
13.	CS+	2	3	3	4	3	5	4	4
	CS-	1	1	2	2	3	2	4	1
14.	CS+	1	5	5	5	5	5	4	5
	CS-	3	4	2	1	2	1	1	1
15.	CS+	0	2	3	5	4	4	3	5
	CS-	1	1	0	2	1	2	2	0

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Sim-L; Bright+ (Continued)									
16.	CS+	0	0	2	1	2	2	3	4
	CS-	1	0	0	0	0	0	0	0
17.	CS+	1	4	3	4	4	4	5	5
	CS-	1	2	2	3	0	1	3	1
18.	CS+	0	2	2	5	5	5	5	5
	CS-	3	2	3	2	3	0	1	0
19.	CS+	3	2	4	5	4	5	4	5
	CS-	1	1	0	0	0	2	2	1
20.	CS+	3	4	4	5	5	5	5	5
	CS-	3	2	2	1	0	2	0	0
21.	CS+	2	2	5	4	3	1	2	2
	CS-	2	2	3	2	4	1	1	0
22.	CS+	2	5	4	5	5	5	5	5
	CS-	2	5	4	2	3	2	2	1
23.	CS+	0	3	4	4	3	3	4	5
	CS-	0	0	0	0	0	0	0	0
24.	CS+	1	1	2	2	5	2	4	4
	CS-	1	1	2	3	0	2	3	1
25.	CS+	1	0	0	2	4	3	5	4
	CS-	2	1	2	0	1	3	5	2
26.	CS+	1	3	5	5	4	3	5	5
	CS-	1	1	0	0	0	1	0	0
27.	CS+	3	1	4	4	3	5	4	4
	CS-	3	2	0	2	0	2	2	2
28.	CS+	1	2	4	4	3	3	2	5
	CS-	0	1	3	3	1	0	2	1
29.	CS+	3	5	4	5	5	4	5	5
	CS-	3	1	2	3	3	3	2	1
30.	CS+	2	4	3	3	3	5	4	2
	CS-	2	4	4	4	3	4	3	1

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Sim-S; Dim+									
1.	CS+	1	0	1	1	2	2	1	2
	CS-	0	0	0	0	0	1	0	2
2.	CS+	0	1	1	1	0	1	2	4
	CS-	0	0	0	0	0	0	1	0
3.	CS+	2	4	3	3	2	2	4	3
	CS-	5	3	4	4	3	2	1	1
4.	CS+	0	0	0	0	0	0	0	1
	CS-	1	0	0	1	0	0	0	0
5.	CS+	1	0	1	0	1	2	2	1
	CS-	0	0	0	0	0	1	1	1
6.	CS+	4	5	2	5	5	3	4	3
	CS-	4	4	2	4	4	4	4	5
7.	CS+	2	2	0	1	0	1	1	1
	CS-	2	2	0	0	0	0	1	0
8.	CS+	0	0	0	0	0	0	0	0
	CS-	0	0	0	0	0	0	0	0
9.	CS+	2	4	4	4	4	4	4	5
	CS-	3	5	4	4	1	4	3	4
10.	CS+	1	2	1	0	2	0	2	1
	CS-	0	1	1	0	0	0	0	0
11.	CS+	1	0	2	2	2	4	4	3
	CS-	0	0	0	0	0	3	0	1
12.	CS+	0	0	0	0	0	0	0	2
	CS-	0	0	0	1	0	0	0	0
13.	CS+	1	0	2	3	4	1	4	4
	CS-	0	0	0	1	1	1	3	1
14.	CS+	2	1	0	1	1	1	1	2
	CS-	3	2	0	0	0	0	0	0
15.	CS+	0	2	2	0	0	0	0	1
	CS-	0	0	0	0	0	0	0	0

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Sim-S; Dim+ (Continued)									
16.	CS+	0	1	0	1	0	1	0	0
	CS-	0	0	0	0	0	0	0	0
17.	CS+	2	2	1	1	3	1	2	3
	CS-	0	3	2	2	2	1	1	1
18.	CS+	2	2	2	3	2	0	4	3
	CS-	2	1	1	1	1	1	1	3
19.	CS+	1	1	2	2	2	3	4	3
	CS-	1	1	1	1	1	2	2	1
20.	CS+	0	3	3	4	3	4	4	5
	CS-	1	4	3	2	3	1	1	2
21.	CS+	1	3	3	4	2	4	3	4
	CS-	0	1	1	2	2	4	4	4
22.	CS+	0	2	0	1	2	1	1	2
	CS-	1	1	0	1	1	0	1	0
23.	CS+	0	0	2	2	2	1	3	2
	CS-	0	0	0	0	1	0	1	0
24.	CS+	0	3	5	2	2	1	3	4
	CS-	2	4	3	3	1	1	2	0
25.	CS+	0	2	3	3	5	4	3	5
	CS-	1	0	1	2	1	2	2	2
26.	CS+	0	1	2	3	0	3	2	1
	CS-	3	0	1	3	0	1	0	1
27.	CS+	0	0	0	0	2	3	4	3
	CS-	0	3	1	0	2	3	4	1
28.	CS+	2	0	0	0	3	4	1	3
	CS-	0	0	1	0	1	0	0	1
29.	CS+	1	2	0	2	2	2	3	1
	CS-	2	0	1	2	1	2	1	2
30.	CS+	1	0	4	2	3	5	3	4
	CS-	0	0	2	0	1	1	2	0

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Sim-S; Bright+									
1.	CS+	3	3	2	4	5	4	4	3
	CS-	1	0	2	2	1	4	3	1
2.	CS+	0	1	3	2	3	4	1	3
	CS-	2	2	2	2	2	2	1	1
3.	CS+	2	3	1	3	3	2	5	4
	CS-	0	2	1	1	2	2	4	4
4.	CS+	1	2	4	3	5	5	2	4
	CS-	0	2	3	1	2	0	0	0
5.	CS+	1	0	0	1	3	0	0	1
	CS-	0	0	0	0	0	0	0	1
6.	CS+	1	1	0	1	3	2	2	3
	CS-	0	0	0	1	0	0	0	2
7.	CS+	3	1	2	3	3	1	3	2
	CS-	1	1	1	1	0	1	2	0
8.	CS+	0	0	0	0	0	0	0	0
	CS-	0	0	0	0	0	0	0	0
9.	CS+	1	4	5	5	4	5	5	5
	CS-	1	3	4	3	2	5	4	4
10.	CS+	2	2	4	4	2	3	4	5
	CS-	2	3	4	2	1	1	3	0
11.	CS+	3	4	4	5	4	5	4	5
	CS-	3	4	5	5	4	4	5	3
12.	CS+	1	1	1	0	1	0	0	2
	CS-	0	1	1	0	1	0	0	0
13.	CS+	0	3	3	5	4	4	5	4
	CS-	1	1	1	4	2	3	3	4
14.	CS+	1	2	3	5	4	4	3	4
	CS-	0	0	2	2	3	2	3	1
15.	CS+	3	3	3	3	5	4	3	4
	CS-	0	1	1	2	4	2	3	3

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Sim-S; Bright+ (Continued)									
16.	CS+	0	1	0	0	1	4	1	2
	CS-	0	0	0	0	0	1	0	0
17.	CS+	0	0	0	1	3	5	4	4
	CS-	0	0	0	2	2	4	1	3
18.	CS+	3	5	5	5	2	3	4	5
	CS-	4	3	3	2	1	0	1	2
19.	CS+	2	4	3	3	4	4	5	4
	CS-	3	4	3	2	2	3	3	3
20.	CS+	0	0	0	0	0	0	0	2
	CS-	0	0	0	0	0	0	0	0
21.	CS+	1	2	4	4	5	4	3	4
	CS-	1	4	3	3	3	1	3	3
22.	CS+	5	5	5	4	5	5	4	5
	CS-	3	2	1	3	0	1	2	0
23.	CS+	0	0	0	3	3	2	0	1
	CS-	0	0	1	0	0	3	0	2
24.	CS+	2	0	1	1	3	3	1	2
	CS-	1	1	0	1	1	1	2	2
25.	CS+	0	0	3	4	5	4	2	3
	CS-	0	0	0	0	1	1	0	0
26.	CS+	1	2	0	2	1	1	4	4
	CS-	0	1	0	1	1	1	3	2
27.	CS+	1	0	5	4	1	4	5	3
	CS-	1	1	2	3	2	2	1	2
28.	CS+	1	1	3	1	4	4	3	4
	CS-	0	1	2	3	2	2	3	3
29.	CS+	2	2	4	2	5	5	5	5
	CS-	1	3	5	4	5	5	5	5
30.	CS+	0	2	1	1	1	1	3	1
	CS-	0	1	0	0	1	2	1	1

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Seq; Dim+									
1.	CS+	4	3	4	1	5	5	4	4
	CS-	3	1	0	0	0	0	1	0
2.	CS+	0	1	2	2	3	3	2	4
	CS-	1	2	3	5	2	3	3	3
3.	CS+	3	5	4	5	3	5	4	3
	CS-	4	4	5	5	5	5	4	4
4.	CS+	2	3	3	4	4	4	4	4
	CS-	0	5	3	5	3	3	1	2
5.	CS+	2	3	5	5	5	5	4	5
	CS-	3	4	5	5	5	5	4	3
6.	CS+	4	2	2	1	1	1	1	2
	CS-	2	1	2	3	3	0	1	2
7.	CS+	3	3	3	5	4	5	5	5
	CS-	1	3	4	5	5	3	5	4
8.	CS+	2	3	5	4	5	5	5	5
	CS-	4	5	3	3	3	3	0	0
9.	CS+	3	5	4	5	4	5	5	5
	CS-	4	5	4	5	5	5	5	5
10.	CS+	2	0	2	2	0	3	4	4
	CS-	0	0	1	3	3	3	1	2
11.	CS+	0	0	0	0	0	0	0	2
	CS-	0	0	1	0	0	0	1	0
12.	CS+	3	5	4	5	4	4	5	4
	CS-	2	4	5	5	4	5	4	5
13.	CS+	0	0	0	0	0	0	0	0
	CS-	0	0	0	1	0	0	2	1
14.	CS+	3	5	3	4	3	5	3	5
	CS-	3	3	5	4	4	4	3	4
15.	CS+	2	3	1	3	4	4	4	4
	CS-	1	4	3	2	3	2	4	3

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Seq; Dim+ (Continued)									
16.	CS+	5	5	4	3	4	5	4	4
	CS-	5	4	5	4	3	4	5	3
17.	CS+	2	2	5	5	5	5	4	5
	CS-	4	4	4	2	1	4	3	3
18.	CS+	1	0	1	2	3	3	2	4
	CS-	2	1	4	2	4	5	3	3
19.	CS+	2	5	5	5	5	5	5	5
	CS-	4	5	5	5	5	5	5	5
20.	CS+	2	3	2	4	3	3	4	3
	CS-	4	5	4	2	3	4	4	4
21.	CS+	3	4	4	3	2	2	3	3
	CS-	4	4	4	2	2	1	2	2
22.	CS+	1	1	0	0	0	0	3	3
	CS-	2	1	1	1	1	2	2	2
23.	CS+	1	3	5	5	5	4	5	5
	CS-	3	4	5	4	3	4	5	2
24.	CS+	2	5	3	4	3	4	4	5
	CS-	1	3	2	4	5	2	3	2
25.	CS+	3	1	4	1	5	2	3	1
	CS-	4	4	5	3	5	3	4	0
26.	CS+	0	0	0	0	2	4	5	5
	CS-	0	0	0	2	2	5	5	5
27.	CS+	3	5	4	4	5	5	4	5
	CS-	5	2	5	4	3	4	3	3
28.	CS+	2	3	3	4	4	5	5	5
	CS-	4	4	4	5	4	4	5	3
29.	CS+	4	5	5	4	5	5	5	5
	CS-	3	3	0	1	1	3	2	1
30.	CS+	0	0	1	0	1	3	1	0
	CS-	3	0	1	2	0	0	2	1

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Seq; Bright+									
1.	CS+	2	2	2	1	3	5	4	5
	CS-	2	0	0	1	2	3	1	3
2.	CS+	0	1	5	5	5	5	5	5
	CS-	0	2	1	2	0	1	0	1
3.	CS+	0	2	3	3	3	3	2	2
	CS-	1	1	4	3	2	2	0	0
4.	CS+	2	0	2	4	4	5	5	3
	CS-	0	0	1	2	0	4	2	1
5.	CS+	1	0	2	4	4	4	5	5
	CS-	0	0	2	0	0	0	0	0
6.	CS+	5	5	5	5	5	5	5	5
	CS-	5	5	5	4	2	4	2	5
7.	CS+	4	4	4	5	5	5	5	5
	CS-	4	0	0	2	0	2	3	1
8.	CS+	0	0	0	0	3	0	1	0
	CS-	0	0	0	0	0	1	0	0
9.	CS+	3	3	4	4	4	5	5	5
	CS-	3	3	2	3	0	3	4	4
10.	CS+	4	5	5	5	5	5	5	5
	CS-	5	5	5	4	3	2	2	3
11.	CS+	5	4	5	5	5	5	5	5
	CS-	3	2	2	3	1	2	2	1
12.	CS+	2	4	2	4	3	4	5	3
	CS-	1	1	0	0	0	1	2	0
13.	CS+	0	0	3	3	1	4	4	4
	CS-	0	0	0	0	0	0	0	0
14.	CS+	0	3	2	0	1	3	2	4
	CS-	1	0	1	1	2	0	0	1
15.	CS+	1	1	4	4	2	4	4	4
	CS-	0	2	3	0	1	4	4	3

Subject	Stimulus	Blocks of Ten Trials							
		1	2	3	4	5	6	7	8
Group Seq; Bright + (Continued)									
16.	CS+	0	3	4	4	4	5	5	4
	CS-	0	1	0	1	1	3	2	0
17.	CS+	4	5	3	5	5	4	4	4
	CS-	2	2	2	2	1	2	2	0
18.	CS+	2	2	2	4	5	5	5	4
	CS-	4	1	3	0	0	2	0	2
19.	CS+	3	3	3	0	2	2	2	2
	CS-	1	1	0	1	0	1	1	0
20.	CS+	0	0	0	0	1	3	3	4
	CS-	0	0	0	0	0	0	0	1
21.	CS+	0	0	0	0	0	0	0	0
	CS-	0	0	0	0	0	0	0	0
22.	CS+	2	0	3	3	3	3	5	5
	CS-	1	1	2	1	2	1	1	1
23.	CS+	2	4	5	5	3	5	3	4
	CS-	3	4	1	1	1	0	1	0
24.	CS+	2	5	5	5	5	5	5	2
	CS-	4	2	1	4	1	1	2	0
25.	CS+	0	0	0	0	1	2	1	4
	CS-	0	0	0	0	0	1	0	3
26.	CS+	0	0	0	2	2	1	1	2
	CS-	0	0	0	0	0	0	2	0
27.	CS+	1	5	4	5	5	4	5	5
	CS-	0	0	0	0	0	0	0	0
28.	CS+	0	4	4	5	4	5	4	4
	CS-	0	0	2	1	0	0	1	1
29.	CS+	3	4	5	5	4	5	5	4
	CS-	0	1	1	1	1	0	1	0
30.	CS+	3	5	5	4	2	5	4	5
	CS-	2	1	2	1	2	3	2	3

Appendix F
Extinction Data

Blocks of Five Trials					Blocks of Five Trials				
Subject	1	2	3	4	Subject	1	2	3	4
Group C									
1.	1	1	3	1	10.	3	0	0	1
2.	1	0	1	2	11.	3	1	1	0
3.	4	4	2	1	12.	3	3	1	1
4.	3	0	1	2	13.	1	1	0	0
5.	1	0	1	1	14.	1	0	0	2
6.	2	3	1	0	15.	3	4	3	5
7.	0	0	0	1	16.	3	0	0	0
8.	5	0	5	2	17.	5	4	3	1
9.	3	1	0	0	18.	1	0	2	2
Group Sim-L; CS+									
1.	1	0	1	0	7.	1	0	0	0
2.	2	0	0	1	8.	2	0	0	0
3.	2	2	1	0	9.	4	4	3	4
4.	4	0	1	2	10.	1	1	0	3
5.	1	0	0	0	11.	0	0	0	0
6.	2	1	0	0	12.	2	0	0	0
Group Sim-L; CS ₁ +									
1.	0	0	0	0	7.	4	3	4	3
2.	0	0	0	1	8.	0	0	0	0
3.	1	0	1	0	9.	1	1	1	2
4.	2	1	0	1	10.	0	0	0	0
5.	4	0	0	0	11.	1	1	1	0
6.	0	1	0	0	12.	2	1	0	0
Group Sim-L; CS ₂ +									
1.	0	0	0	2	7.	1	1	2	1
2.	0	0	0	0	8.	1	0	0	0
3.	0	0	0	0	9.	4	5	4	3
4.	1	1	0	0	10.	1	2	0	3
5.	1	0	0	1	11.	3	3	1	0
6.	0	0	0	1	12.	3	2	1	2

Subject	Blocks of Five Trials				Subject	Blocks of Five Trials			
	1	2	3	4		1	2	3	4

Group Sim-L; CS₁-

1.	0	1	1	2	7.	2	2	1	0
2.	1	1	0	0	8.	2	0	0	0
3.	3	2	0	0	9.	0	1	0	0
4.	0	0	0	0	10.	3	0	0	0
5.	1	0	0	0	11.	0	0	0	0
6.	3	1	0	0	12.	5	3	0	1

Group Sim-L; CS₂-

1.	0	0	0	0	7.	2	0	2	3
2.	0	0	0	0	8.	1	0	0	0
3.	1	2	0	0	9.	1	3	1	1
4.	0	1	2	1	10.	1	0	1	0
5.	0	2	0	0	11.	0	0	0	1
6.	1	2	1	2	12.	2	2	2	2

Group Sim-S; CS+

1.	1	0	0	0	7.	3	4	3	1
2.	0	0	0	0	8.	1	0	0	0
3.	1	0	0	0	9.	4	3	4	3
4.	0	0	0	0	10.	4	3	0	1
5.	1	1	1	1	11.	0	1	0	0
6.	4	4	5	3	12.	5	1	1	1

Group Sim-S; CS₁+

1.	2	1	0	0	7.	2	2	0	2
2.	0	0	0	0	8.	0	0	0	0
3.	3	0	1	0	9.	2	4	0	1
4.	0	0	0	0	10.	0	2	0	0
5.	2	2	2	2	11.	3	5	4	5
6.	0	0	0	0	12.	1	0	0	1

Group Sim-S; CS₂+

1.	0	0	0	0	7.	3	0	0	0
2.	0	0	0	0	8.	4	1	1	2
3.	0	0	0	0	9.	2	2	2	1
4.	0	0	0	0	10.	0	0	0	0
5.	1	1	0	0	11.	2	0	1	1
6.	2	1	0	0	12.	5	3	4	1

Subject	Blocks of Five Trials				Subject	Blocks of Five Trials			
	1	2	3	4		1	2	3	4

Group Sim-S; CS₁-

1.	4	0	2	1	7.	1	2	0	0
2.	3	2	3	0	8.	0	0	0	0
3.	2	1	1	4	9.	2	1	1	2
4.	0	0	0	0	10.	0	0	0	1
5.	1	0	0	0	11.	1	0	0	0
6.	0	0	0	1	12.	1	1	1	2

Group Sim-S; CS₂-

1.	1	1	1	1	7.	0	0	0	0
2.	0	0	0	0	8.	1	0	0	1
3.	1	1	0	1	9.	0	0	0	1
4.	0	0	1	0	10.	1	0	0	0
5.	1	0	0	0	11.	3	2	1	1
6.	1	2	1	1	12.	0	0	0	0

Group Seq; CS₁+

1.	1	2	0	1	7.	4	4	4	2
2.	2	0	0	1	8.	1	0	0	0
3.	2	0	3	1	9.	1	4	0	3
4.	1	1	0	0	10.	3	0	1	1
5.	4	4	5	3	11.	1	2	2	3
6.	1	0	1	0	12.	5	5	3	4

Group Seq; CS₁+

1.	2	2	3	4	7.	3	3	2	0
2.	1	0	0	0	8.	0	0	0	0
3.	5	5	3	1	9.	3	2	4	2
4.	2	0	0	1	10.	3	3	3	2
5.	1	0	0	2	11.	3	1	0	0
6.	3	5	3	5	12.	0	0	0	0

Group Seq; CS₂+

1.	0	0	0	0	7.	0	1	0	0
2.	0	0	0	0	8.	0	0	0	0
3.	0	2	1	1	9.	3	0	1	0
4.	3	1	2	1	10.	1	1	1	0
5.	0	1	1	1	11.	1	0	0	0
6.	0	0	0	0	12.	2	0	1	1

Blocks of Five Trials					Blocks of Five Trials				
Subject	1	2	3	4	Subject	1	2	3	4
Group Seq; CS ₁ -									
1.	5	4	5	5	7.	0	1	0	1
2.	1	1	0	0	8.	0	0	0	1
3.	0	0	1	1	9.	0	0	0	2
4.	0	0	0	0	10.	0	4	4	1
5.	0	0	1	0	11.	0	0	0	0
6.	4	2	1	0	12.	1	0	2	2
Group Seq; CS ₂ -									
1.	0	0	0	3	7.	0	0	1	0
2.	1	0	1	1	8.	1	0	0	0
3.	2	3	0	0	9.	0	0	0	0
4.	2	2	0	3	10.	1	1	0	1
5.	2	1	1	0	11.	1	0	1	1
6.	0	1	0	1	12.	1	2	1	3

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Date: May 26, 1964

