Transfer of Training Between Sensory Modes

Technical Report #3

DISINHIBITION IN COMPOUND CONDITIONING AS A FUNCTION OF THE NUMBER OF REINFORCEMENTS OF A SINGLE CONDITIONED STIMULUS

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I

SUMMARY

This experiment tested the hypothesis that the relationship between the number of reinforcements and the magnitude of the conditioned GSR would differ depending upon whether the original CS was employed in the test situation or a compound CS containing the original CS and an extra stimulus of another sense modality was used. It was expected that the single CS function would first rise and then fall, as a result of the development of conditioned inhibition. On the assumption that the extra stimulus in the compound CS would disinhibit the conditioned inhibition, it was expected that the function would rise continuously in the compound CS situation.

One hundred and eight Ss were divided into two groups depending upon whether a visual or auditory CS was used during training. The visual CS was a 1/4 inch square white light of 0.36 ft./candles and the auditory CS was a 1,000 cps tone of 63 db (physical reference), in a background of 42 db air conditioning noise. The stimuli had a duration of 1.0 second. The UCS was an electric shock to the finger tips, which followed the onset of the CS by 0.9 seconds and terminated with the CS.

The visual and auditory CS groups were subdivided into thirds to receive either four, eight, or twelve reinforcements prior to the test trials. Within each reinforcement subgroup, twelve Ss were tested on the compound of light and tone presented simultaneously and six Ss were tested on the single CS which had been reinforced. The dependent

variable was the square root of conductance change during the three seconds following the offset of the test stimulus, adjusted to remove the variability due to the correlation between adaptation and test trial responses. The sum of the first two test trials was used to test the hypotheses.

The results showed that the relationship between magnitude of GSR to the compound CS and number of reinforcements was positive and that the magnitude of GSR to the single CS and number of reinforcements went up from four to eight reinforcements and down from eight to twelve reinforcements. This interaction, however, was not statistically significant using the data of the light-CS and tone-CS groups combined, but approached significance in the light-CS group only ($p < .10$). In the tone-CS group the compound CS function was less steep than in the light-CS group and, in addition, the tone-CS single stimulus function failed to drop from eight to twelve reinforcements as expected.

In spite of the only marginal statistical support given to the hypothesis in the light-CS group only, the results were interpreted as being in essential agreement with the theoretical notion from which the prediction was generated. It was pointed out that the specificity and complexity of the predicted interaction, and the fact that it was generated a priori from theory based on only meager prior data, added to the significance of the results obtained. It was speculated that the differences between the tone-CS and light-CS data may have stemmed from differences in the degree to which each was intrusive as an extra stimulus and, also, to possible differences in intensity and other properties peculiar to each sense modality.

II

BACKGROUND

The Pavlovian concept of disinhibition has been applied to two distinctly different classical conditioning phenomena. The more frequent phenomenon to which the term has been applied is the situation in which an added exteroceptive stimulus, presented simultaneously with a CS, the CR to which has been extinguished, produces a recovery of the original CR (Kimble, 1961). The extra stimulus in such situations presemably inhibits the inhibition which has developed during extinction and, thus, restores the original CR. Pavlov (1927) also applied the concept to the situation in which an added exteroceptive stimulus, which is presented during reinforcement between the onsets of the CS and the UCS, i.e., during the delay interval, has the effect of bringing forth the CR prematurely and, sometimes, with increased strength. In this case the extra stimulus was assumed to inhibit the inhibition of delay, thus releasing the CR.

In the present experiment the number of reinforcements of a conditioned stimulus, prior to the addition of an extra, disinhibiting stimulus, was the primary parameter of the disinhibition process studied. Previous studies of the acquisition process during classical GSR conditioning (Kimmel, 1959; Meryman, 1953; Stewart, Stern, Winokur, and Fredman, 1961) have shown that the curve of GSR conditioning rises for the first few conditioning trials and, then, drops gradually with continued reinforcement. While some writers have attributed this negative trend

in the latter portion of the GSR conditioning curve to an adaptation or habituation process, presumably centered in the response system, such an explanation ignores the not-uncommon finding that changes in the physical characteristics of the CS are followed by increments in GSR magnitude (Grings and Kimmel, 1958; Kimmel, 1960; Wickens, Schroder, and Snide, 1953). A basic assumption underlying the present experiment was that the decrement in the latter portion of the GSR conditioning function results from the gradual development of a conditioned inhibitory process, probably under the control of the CS, and that this inhibitory process may be disinhibited in any one of several ways.

For the present experiment, disinhibition was defined operationally as the result of adding an extra stimulus of a different sense modality than the CS which had been reinforced either four, eight, or twelve times prior to the disinhibition test. Half of the Ss in the experiment were trained with an auditory CS and half were trained with a visual CS. Compound (i.e., simultaneous) presentation of the auditory and visual stimuli following single-stimulus reinforcement constituted the disinhibition test situation. It was hypothesized that the magnitude of the GSR produced by the compound stimulus and the number of reinforcements given prior to the compound tests would be positively related. Control Ss were run who received their tests on the single stimulus which had been reinforced, to provide baseline data regarding the relationship between the number of reinforcements and the amplitude of the conditioned GSR. It was expected that the control Ss would manifest an increment in magnitude of GSR as a function of the number of reinforcements, up to eight reinforcements, and, then, a decrement from eight to twelve reinforcements, i.e., a different trend from that shown in the compound CS data.

III

METHOD

Subjects

The Ss were 108 undergraduate students registered in introductory psychology courses at the University of Florida. Each was paid $1.00 for participating in the experiment. The Ss were assigned randomly to the experimental conditions, in four separate replications each containing 36 Ss.

Instructions

All instructions were read to S by E. They told S that this was an experiment on the effect of external stimulation on the GSR and that it was necessary for him to relax his body, avoid unnecessary or sudden movements, and pay close attention to the stimuli.

Apparatus

The auditory CS was a 1,000 cps tone produced by a General Radio Company audio oscillator (1210-C), amplified by a General Radio Company amplifier (1206-B), and delivered to S via a single Trimm, Inc. earphone (ANB-H-1) which was suspended in a stimulus panel approximately 30 inches in front of the S's head. The intensity of the tone, measured by means of a General Radio Company sound pressure-level meter, with the remote microphone approximately six inches in front of the sound source, was 64 db (physical reference). An air conditioning noise (which was on during the experiment but not during the time that the intensity of the tone was measured) registered 42 db

(physical reference) on the meter. Against the background of the air conditioning noise, the auditory CS was a very mild, but definitely suprathreshold stimulus.

The visual CS was a 1/4 inch square white light, produced by a 35 mm. projector located in the same stimulus panel which housed the sound source, at approximate eye level. The light was attenuated by neutral density filters so that its illuminance, measured by means of a MacBeth illuminometer placed directly over the 1/4 inch opening in the stimulus panel, averaged 0.36 ft./candles over ten readings.

The UCS was an electric shock delivered via silver electrodes to the index and middle finger tips of the S's left hand. It was produced by a Psychological Instruments Company electro-stimulator (1-A) and its intensity (for an S with a skin resistance of 25,000 ohms) was approximately 50 volts and 2.0 milliamperes.

The duration of the tone and light CSs was 1.0 seconds. During reinforced trials the onset of the electric shock UCS followed that of the CS by 0.9 seconds and both stimuli terminated simultaneously! Temporal relations were controlled by two Hunter interval timers. Onsets of both the CS and the UCS were recorded by signal-pens on the GSR record.

The GSR was picked up as a DC change in resistance from the palm and back of the S's right hand by 3/4 inch zinc electrodes covered with a few drops of zinc sulphate solution, in lucite cups filled with saline electrode jelly. It was amplified by a Hunter GSR apparatus and recorded on a Esterline-Angus ink-writing milliammeter with a paper speed of three inches per minute. The GSR was measured as the maximum deflection of the recorder pen within the three second interval beginning with the offset of the CS. This was transformed into square

root of conductance change for statistical purposes.

Design

Half of the Ss were conditioned with the auditory CS and half with the visual CS. Each of these two groups was divided into thirds, to receive different numbers of reinforcements, four, eight, or twelve. This double-classification of the 108 Ss produced six subgroups of 18 Ss each. Within each of these subgroups, twelve Ss were tested on the compound of light and tone presented simultaneously, while the other six Ss were tested on the single CS with which they had been conditioned.

Procedure

Data were collected in a soundproof, electrically shielded, air conditioned room, illuminated by a 7.5 watt shielded red bulb, located behind S's line of sight to the stimulus panel. E and the equipment were located in an adjoining room. When S arrived at the laboratory his right hand was cleaned with alcohol and the GSR electrodes were attached. S was then taken into the experimental room and seated in a cushioned chair. The GSR pickup leads were attached to the electrodes and the shock electrodes were taped to S's finger tips. E then read the instructions to S. After the instructions had been read, the doors to the experimental room were closed and the experiment begun.

Each S received four adaptation presentations of the CS alone (light or tone, according to group), either four, eight, or twelve reinforced trials of CS paired with shock, and four nonreinforced test, or extinction presentations of either the CS which had been reinforced or the compound of light and tone (according to group).

The inter-trial interval was varied from trial to trial unsystematically between 30 and 60 seconds, throughout the experimental session.

IV

RESULTS

The correlation between the mean GSR during adaptation and the later non-reinforced test trials was determined separately for the 54 Ss conditioned with the light and the 54 Ss conditioned with the tone. It was found to be essentially linear and equal to 0.33 for the light-CS group and 0.70 for the tone-CS group. The test trial responses were adjusted to remove the variation due to the intercorrelation between adaptation and test responses and the resulting values, with 2.00 added to eliminate negative scores, used for the following presentation.

Figure 1 presents the adjusted mean GSRs for the sum of the first two test trials, as a function of the number of reinforcements given during conditioning. Only the first two trials were used because of the reductions in GSR resulting from extinction. The test stimulus condition (i.e., compound CS versus single CS) is the parameter defining the two functions shown in the figure. As is indicated in Figure 1, the group which was tested with the compound CS showed a consistent increase in mean GSR as a function of the number of reinforcements, while the control group, which was tested with either the light or the tone alone, showed an increase in mean GSR from four to eight reinforcements and a decrease from eight to twelve reinforcements.

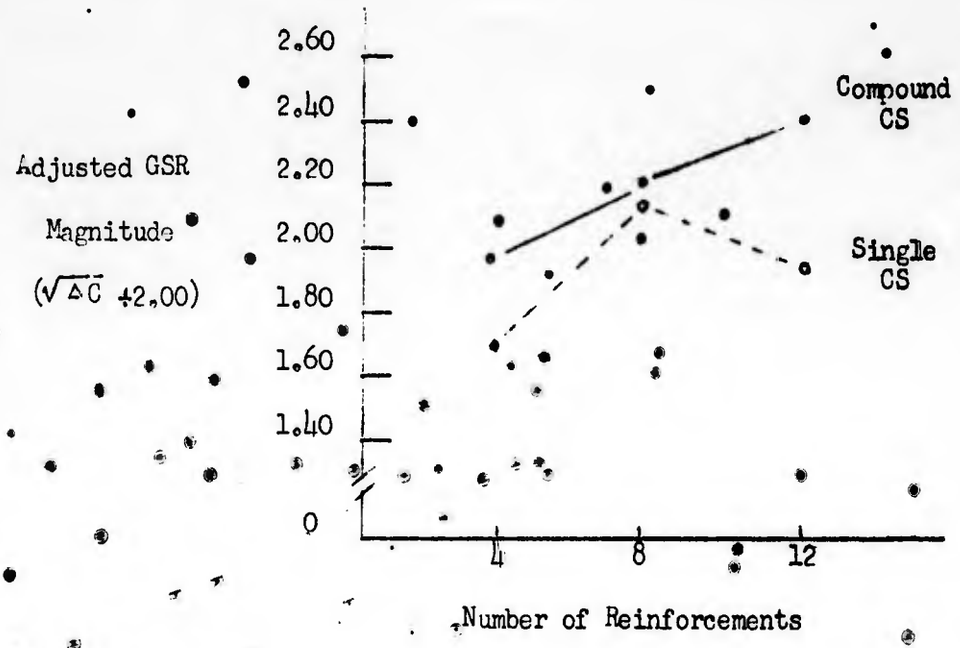

Fig. 1. The relationship between number of reinforcements and magnitude of GSR for compound CS and single CS groups regardless of CS sense mode.

Table 1 presents the analysis of variance of the data depicted in Figure 1. The significant F ratios in Table 1 reflect the fact that a significant overall increase in mean GSR occurred as a function of the number of reinforcements and that the mean response to the compound CS was significantly greater than that to the single CS. The interaction between number of reinforcements and test condition failed to achieve significance, however, as had been hypothesized.

TABLE 1

ANALYSIS OF VARIANCE OF ADJUSTED GSRs, SUMMED FOR FIRST TWO TEST TRIALS

Source	df	Mean Square	F
Number of reinforcements	2	6.3249	4.25*
Test condition	1	8.6000	5.77**
N x Test	2	1.6241	1.09
Error	102	1.4901	-

* $p < .01$

** $p < .025$

Further analysis of the data shown in Figure 1 indicated that the interaction between number of reinforcements and test condition tended to differ for the two groups which were trained with different CSs ($0.20 > p > 0.10$). Figures 2 and 3 present the adjusted mean GSRs for the sum of the first two test trials, as a function of the number of reinforcements, separately for the light-CS and tone-CS groups. The test stimulus condition is again the parameter defining the separate functions shown in each figure. As is indicated in Figures 2 and 3, the hypothesized interaction between number of reinforcements and test condition was manifested to a greater extent in the light-CS group than in the tone-CS group. The tone-CS group's compound CS function was less steep than that of the light-CS group and, in addition, the tone-CS group's single stimulus function failed to show a decrease in response from eight to twelve reinforcements as had been expected

(although some change in the slope of the function is noticeable at eight reinforcements).

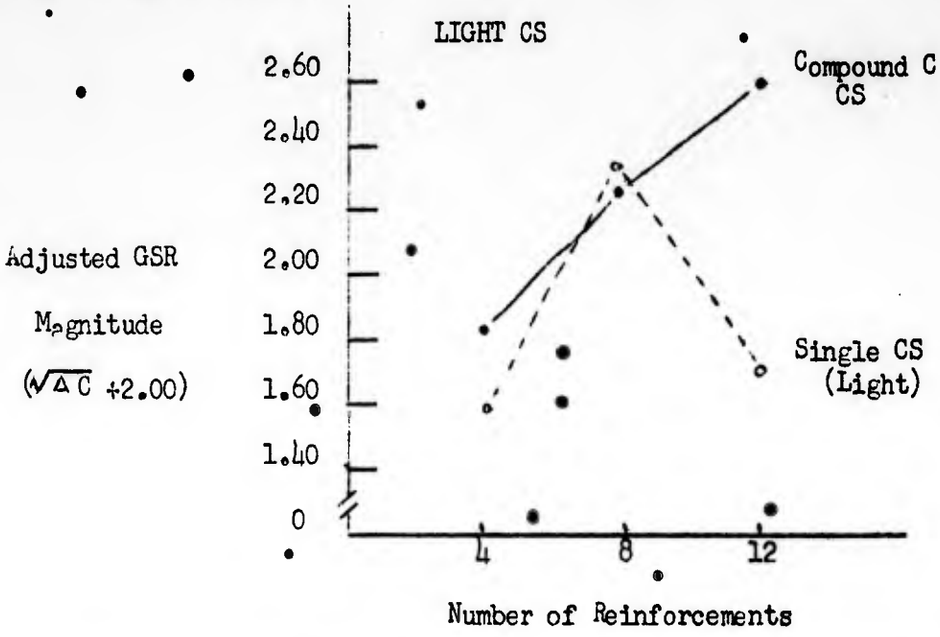

Fig. 2. The relationship between number of reinforcements and magnitude of GSR for compound CS and single CS groups conditioned with a visual CS.

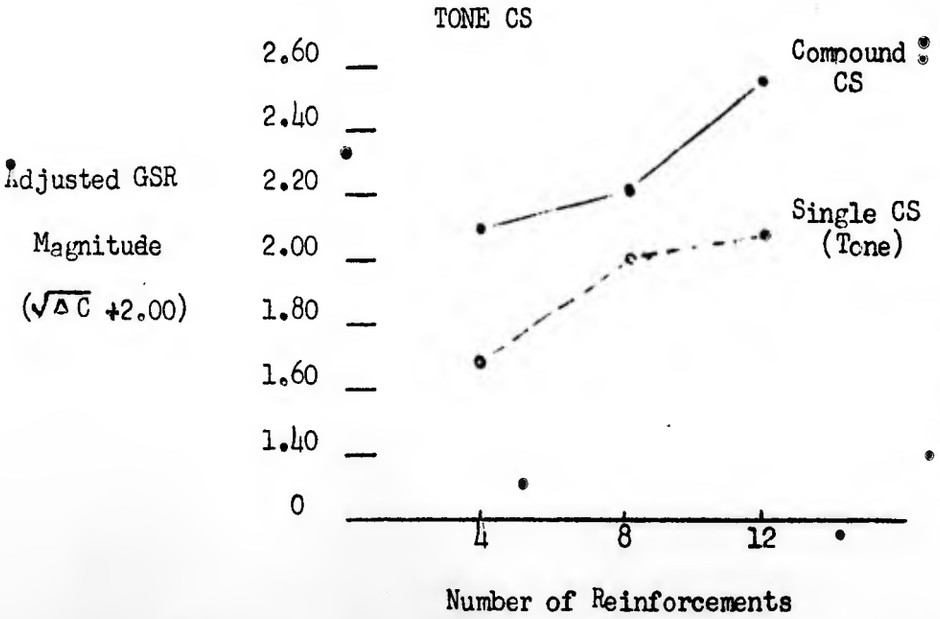

Fig. 3. The relationship between number of reinforcements and magnitude of GSR for compound CS and single CS groups conditioned with an auditory CS.

A separate analysis of variance was done using only the data of the light-CS group. This analysis is shown in Table 2. As is indicated in Table 2, the effects of number of reinforcements and test condition were both significant and the interaction between number of reinforcements and test condition reached the 10% level of significance. The mean difference between the two groups which received twelve reinforcements was highly significant (t = 2.90, df = 48), this being the only point in the reinforcement function at which the two groups differed significantly.

TABLE 2

ANALYSIS OF VARIANCE OF ADJUSTED GSRs, SUMMED FOR TWO TEST TRIALS: LIGHT-CS GROUPS ONLY

Source	df	Mean Square	F
Number of reinforcements	2	6.7149	4.75*
Test condition	1	5.9408	4.20**
N x test	2	3.5133	2.48***
Error	48	1.4142	-

* $p < .025$

** $p < .05$

*** $p < .10$

V

DISCUSSION

The major hypothesis evaluated in this experiment, that a different relationship between number of reinforcements and magnitude of test trial GSRs would be found in the two groups which were tested on either the compound or single CS, received only weak statistical support in the data of the light-CS group and none at all in the tone-CS group. Considering the complexity and the specificity of the predicted interaction, however, along with the need to evaluate the hypothesis by means of a relatively insensitive "between Ss" error estimate (and with a two-tailed test), the results are interpreted as in essential agreement with the theoretical notion from which the prediction was generated. No one will be surprised to learn that two stimuli produced larger GSRs than did one stimulus, but the fact that this effect was significant after twelve reinforcements in the light-CS group, but not after either four or eight reinforcements, definitely supports the argument that the extra stimulus had the effect of releasing the inhibition which led to the reduction in the single stimulus function after eight reinforcements.

The difference between the light-CS and tone-CS interactions is deserving of some consideration. It is not unlikely that a tone added to the environment of an S who had been attending to a light is more intrusive than is a light which is added to the environment of an S who has been attending to a tone. It may be possible that some of the

tone-CS Ss did not immediately notice the added light, but the parallel of this possibility in the light-CS group seems much less likely. These considerations would explain the fact that the compound stimulus function was steeper in the light-CS group than in the tone-CS group.

The fact that the single stimulus functions also were different for the two groups was unexpected. Previous work in this area using auditory CSs (Kimmel, 1959; Meryman, 1953) had led the present experimenters to anticipate that the highest point in the reinforcement curves for both CSs would be at eight reinforcements. A major difference between the two earlier studies and the present study can be found in the fact that the present study used a much shorter CS-UCS interval than was used in the earlier studies. It seems reasonable to assume that, it the decrement in the latter portion of the GSR conditioning curve is the result of the development of conditioned inhibition, under the control of the CS, that the rate at which such an inhibitory process develops may depend upon the CS-UCS interval used. A recent experiment using an auditory CS and the conditioned GSR (Grings, Lockhart, and Dameron, 1961) found that the highest point in the conditioning function was at six reinforcements when the interstimulus interval was 5.0 seconds, but that the function was still rising after eight reinforcements when the interstimulus interval was only 0.5 seconds. With these considerations in mind, it must be assumed that the sense modality of the CS operated in conjunction with the interstimulus interval in determining the point along the GSR conditioning function at which its highest value occurred. It cannot be said which aspect of the difference between sense modalities was the most critical, but it is reasonable to assume for the present experiment that an intensity difference was a least partly involved. During the adaptation phase of the present experiment the mean response

to the light CS was 0.95, while to the tone CS it was 1.09, a difference which approached significance ($0.20 > p > 0.10$). The suggestion is that the more intense CS may require a greater number of trials to reach the highest point in its GSR conditioning curve, although this suggestion is offered as hardly more than base speculation. Obviously, the inhibitory process which was studied in this experiment is no less complicated that most other classical conditioning processes.

VI

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