

Effects of partial and continuous reinforcement on acquisition and extinction of the skin conductance response

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Four groups of human subjects received the unconditioned stimulus (UCS) paired with the conditioned stimulus (CS) either 25%, 50%, 75%, or 100% of the time. Four other groups were matched to the paired groups in terms of the number of UCSs, except that they were presented along with the CS in an unpaired random order. Through 20 acquisition trials, the only groups to demonstrate classical conditioning of the skin conductance response (SCR) were the 75% and 100% groups. There were no significant differences in trials to criterion during extinction between the various groups, and therefore no evidence for the partial reinforcement effect (PRE). The results were discussed in terms of the relationship between magnitude of the conditioned response (CR) during acquisition and resistance to extinction. The present study also provided one more example of the discrepant results between somatic and autonomic responses.

The literature is sparse concerning partial reinforcement of the skin conductance response (SCR), particularly recently. Some earlier studies (e.g., Grant, Meyer, & Hake, 1950; Humphreys, 1940; Merister & Doerfler, 1954) made attempts to demonstrate the partial reinforcement effect (PRE) using the SCR and were somewhat successful in that lower percentages of reinforcement led to higher magnitude values during extinction. None, however, looked at resistance to extinction in terms of the number of trials to criterion.

More recently, one study by Yarczower, Vlases, and Friedman (1960) did use trials to criterion, but only provided minimal support for the PRE. Six groups were used with only five subjects in each group. Using a 2 by 3 design, groups received either 10 or 30 presentations of the conditioned stimulus (CS) paired with the unconditioned stimulus (UCS) on 10%, 30%, or 100% of the trials. The only support shown for the PRE here was between the 30% and 100% groups for subjects receiving 30 trials. The mean number of trials to criterion for the 30% group was about 15 compared to a mean of about 7 for the 100% group. Wilcoxon's test for unpaired replicates indicated a significant difference between the two groups. No unpaired control groups were run, so the effects of pairing during acquisition could not be determined. As well, lack of acquisition data made it impossible to determine the effects of a partial reinforcement procedure on the CR during acquisition. Therefore, the small number of subjects in each group, the lack of control groups during acquisition, the small group differences obtained during extinc-

tion, omission of data, and the statistics used all necessitated another look at the partial reinforcement process using the SCR.

Strong resistance to extinction, characteristic of the PRE, has been difficult to achieve with the SCR. Recently, however, Schramm and Kimmel (1970) and Silver and Kimmel (1969) were able to demonstrate strong resistance to extinction by presenting only two acquisition trials beyond the peak CR prior to extinction. During extinction, a mean of approximately 43 trials to a criterion of two consecutive nonresponses was obtained for both studies. On the other hand, subjects who received 16 trials past the peak CR only averaged around 10 trials to criterion. The two conditions also differed with respect to the magnitude of the CR during acquisition, just prior to extinction. Subjects in the 16-postpeak condition had undergone considerable CR attenuation, while subjects who received two trials past the peak exhibited little CR attenuation during training and showed strong resistance to extinction. It therefore appears that any strong resistance to extinction is related to the strength of the CR during acquisition. Either CR attenuation, or failure of the CR to develop, should lead to weak resistance to extinction. It is therefore hypothesized that the PRE will not be demonstrated in the present study, since resistance to extinction in terms of trials to criterion should be approximately the same for all paired groups due to either the failure of a CR to develop in the lower percentage groups or CR attenuation in the higher percentage groups. Also, the effects of pairing will be stronger for the higher percentage groups during acquisition.

Eight groups were employed, four of which received paired CS-UCS trials and four that received unpaired presentations of the CS and UCS. The paired groups

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received the CS paired with the UCS 25%, 50%, 75%, or 100% of the time. The unpaired groups were matched to their paired counterparts in terms of the number of UCSs received, presentation of which was done in a random, unsystematic manner.

METHOD

Subjects and Design

Ninety-two students from introductory psychology classes volunteered to participate in the experiment. The 25% experimental group (25E) had 10 subjects, with Group 75E and the 75% control group (75C) containing 11 subjects. All other groups had 12 subjects with an equal number of males and females in each, except for Group 75E which had five females and six males, Group 25C which had seven females and five males, and Group 75C which had five females and six males.

Apparatus

The subjects were seated in a dark, soundproof IAC chamber. Subjects could communicate with the experimenter at all times through a two-way intercom. The CS was a 39-dB (physical reference), 1,000-Hz tone of 5.0-sec duration, delivered from a Hewlett-Packard Model 200 CD wide-range oscillator to Sharpe Model AV-9 earphones.

An electric shock (UCS) was delivered via copper electrodes attached to the subject's right forearm. It was produced by an Argoneaut Associates constant-current pulse amplifier, Model LRA046, with an intensity of 4.0 mA dc and a duration of .1 sec. Skin resistance was picked up from the palm and back of subject's left hand by zinc-zinc sulfate electrodes in Lucite cups filled with electrode jelly. The SCR was amplified by an Electronic Laboratories, Inc. Model 308C amplifier and recorded

on a Texas Instruments Company Recti-Riter with a paper speed of .127 cm/sec.

Procedure

The subject was seated in an armchair and electrodes and earphones were attached. The lights were turned out and the chamber's doors closed. Instructions were read to the subjects over the intercom. They were told to remain alert and attentive, and to avoid severe and unnecessary movements. Each subject was given three presentations of the UCS alone in increasing intensities of 1.0, 2.5, and 4.0 mA dc (i.e., sensitization), followed by 12 habituation trials of the CS.

All groups received 20 training trials and then all subjects received extinction trials of the CS alone until two consecutive nonresponses or 50 trials, whichever occurred first. The CS-UCS interval was 5.0 sec and the intertrial interval varied from 15 to 45 sec, with a mean of 30 sec. Upon termination of the experiment, the subject was thanked, instructed not to discuss the experiment, and dismissed.

RESULTS

The SCR was transformed to units of log conductance for analysis using the formula: $\log(1/\text{resistance, peak}) - \log(1/\text{resistance, base})$. The effects of a partial reinforcement procedure on the acquisition of a conditioned SCR occurring in the interval between 1.5 and 6.5 sec following the CS are illustrated in Figure 1. The data represent the mean magnitude of the first response made to the CS for paired and unpaired conditions for all levels of reinforcement. Ten blocks of

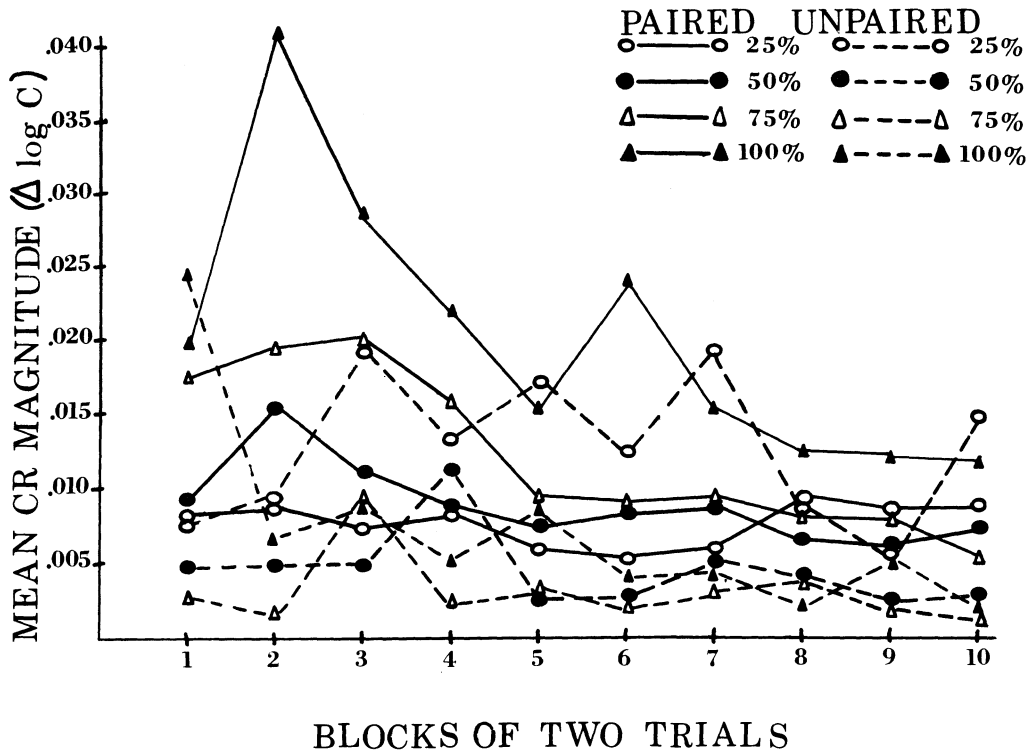


Figure 1. Mean magnitude of SCR for 10 bolocks of two trials during acquisition at all levels of reinforcement for both the paired and unpaired conditions.

DISCUSSION

The only two paired groups to demonstrate conditioning were the ones that received the UCS 75% or 100% of the time. In both cases, the CR reached a peak early during acquisition and then became quickly attenuated. In the other two paired groups, there appeared to be little or no evidence for classical conditioning. All of this seems to have resulted in a lack of significant differences occurring for the different levels of reinforcement during extinction, and appears to be related to the magnitude of the CR during acquisition just prior to extinction. Extinction was begun for the paired groups at a point where the responses made to the CS were barely evident due to either the failure of the CR to develop (e.g., 25% and 50% groups), or CR attenuation which occurred after the peak was reached during acquisition (e.g., 75% and 100% groups). Lack of significant differences during the last five trial blocks when they existed for the first five seemed to support the latter contention.

The means during extinction for trials to criterion in the present experiment were considerably smaller than those obtained in other studies (e.g., Schramm & Kimmel, 1970; Silver & Kimmel, 1969), where CR attenuation was kept at a minimum by beginning extinction following just two acquisition trials past the peak CR. For example, the means for paired groups obtained in the present study ranged from 10.3 to 20.5, while means of approximately 43 were obtained for the Schramm and Kimmel (1970) and Silver and Kimmel (1969) studies.

The lack of a PRE represents another example of the discrepancy between the results obtained for motor vs. autonomic responses, in that many studies have demonstrated the PRE using skeletal response measures (e.g., Grant & Schipper, 1952; Lewis & Duncan, 1956). Silver (1973) recently emphasized this difference when it was demonstrated that prior CS-alone presentations have a facilitatory effect upon a subsequent classical conditioning procedure using the SCR. The opposite has been found with skeletal responses and has come to be known as "latent inhibition" (e.g., Lubow & Moore, 1959). It appears, therefore, that the SCR is sensitive to different phenomena, which is perhaps due to components (e.g., orienting responses) within the SCR that are present to a lesser extent, if at all, in skeletal responses. This hypothesis, while not new, must continue to be entertained.

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two trials during acquisition revealed little or no effects of pairing for the 25% and 50% reinforcement conditions. However, differences between paired and unpaired groups became apparent in the 75% condition, with the largest differences occurring between paired and unpaired groups for the subjects who received the UCS 100% of the time. This was largely due to the subjects in the paired 100% group producing the largest responses, with the second largest responses coming from subjects in the 75% paired condition. Typical of classical conditioning (Kimmel, 1966), the CR for the 75% and 100% groups reached a peak early during acquisition and then quickly became attenuated. Any paired/unpaired differences early in training thus become reduced later on and therefore, seemed to make appropriate an analysis based upon the first part of acquisition. Therefore, an analysis of variance was computed for the first five trial blocks. As expected, there was a significant Pairing by Percentage interaction [$F(3,84) = 2.91, p < .05$] and a significant Pairing by Percentage by Trials interaction [$F(12,336) = 1.85, p < .05$]. The Pairing by Trials interaction was significant [$F(4,336) = 2.42, p < .05$] as well. No other effects were significant. Further analyses showed significant differences between paired and unpaired conditions for the 100% reinforcement groups with the Pairing by Trials interaction being significant [$F(4,88) = 4.09, p < .01$] and a significant main effect for pairing in the 75% groups [$F(1,20) = 12.03, p < .005$]. While the responses made to the CS for the unpaired 25% condition appeared to be larger than those of the 25% paired condition, these differences were not significant. An analysis of variance on the last five trial blocks for all groups revealed no significant effects.

The data for extinction are presented in Table 1. It includes the number of trials to a criterion of two nonresponses. It shows the means and standard deviations for each group, with none of the groups differing significantly from each other. There was a trend, however, indicating that the higher percentage groups responded for a longer period, in that the paired 75% and 100% groups revealed the largest number of trials to criterion. This trend was in the opposite direction to that expected from the PRE.

Table 1
Mean Number of Trials to Criterion During Extinction For the Paired and Unpaired Groups as a Function of the Percentage of Reinforced Trials

	Percentage of Reinforced Trials							
	25%		50%		75%		100%	
	M	SD	M	SD	M	SD	M	SD
Paired	13.6	13.2	10.3	9.8	20.5	18.9	19.0	9.6
Unpaired	11.5	10.3	7.9	6.0	5.9	3.3	10.6	7.5

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