

# Stimulus control of human systolic blood pressure<sup>1</sup>

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For group 1 a light occurred with a blood pressure cuff inflation (CS-) and shock(UCS) followed 9 sec. later while no shock followed cuff inflation alone (CS-). For group 2 CS- was cuff inflation + light while CS+ was the cuff inflation alone followed by shock. The CS+ was significantly higher than the CS- pressure for each group in the conditioning and reconditioning phases suggesting discriminative control had been achieved.

Although several animal investigations report success in conditioning blood pressure (Dykman & Gantt, 1960; Dykman, Mack, & Ackerman, 1965; Girden, 1942), there are no studies which depict the acquisition and extinction of a conditioned human blood pressure response. This paper reports an attempt to bring human systolic blood pressure under stimulus control with a discriminative conditioning procedure.

## Method

The laboratory consisted of two rooms separated by a wall with a one-way vision window. One room housed S, the other E and all the apparatus, chief of which was a 6 channel polygraph (Physiograph E & M Instrument Co.) of modular construction containing a standard plug-in amplifier for recording blood pressure.

The Ss were 10 male and five female undergraduate students in Psychology, ages 18-38, with no history of respiratory or cardio-vascular disease. On order of appearance, the first eight were assigned to group 1, whereas the next seven were assigned to group 2.

An auscultatory cuff automatically inflated every 30 sec. throughout the experiment and was utilized in a Pavlovian discriminative conditioning procedure. For group 1 the CS- was the cuff inflation alone and CS+ was the cuff inflation + simultaneous light. For group 2, CS+ was the cuff inflation alone while CS- was cuff + light. A trial consisted in presenting CS+ always preceded randomly by 1, 2 or 3 CS- inflations (see Fig. 1).

On day 1 Ss underwent four continuous phases. (1) Basal: resting blood pressure data were obtained for 17 min. (33 cuff inflations); (2) Basal Light: 15 trials; (3) Conditioning: 11 trials in which each CS+ was followed by a shock (UCS); (4) Extinction 1: 11 trials. On day 2, about 24 hr. later, three more phases were run continuously; (5) Spontaneous Recovery: 10 trials as in extinction 1; (6) Reconditioning: 10 trials in which each CS+ was followed by a shock (UCS) and (7) Extinction 2: 10 trials.

The light, of 2 sec. duration, was provided by a GE 6-w bulb suspended at eye level approximately 4 ft. from S. The shock was a square wave 50 VAC 2 msec. 25 cps pulse delivered for 3 sec. to the lower right ankle through two silver plated 1-1/2 in. by 2-1/4 in. standard

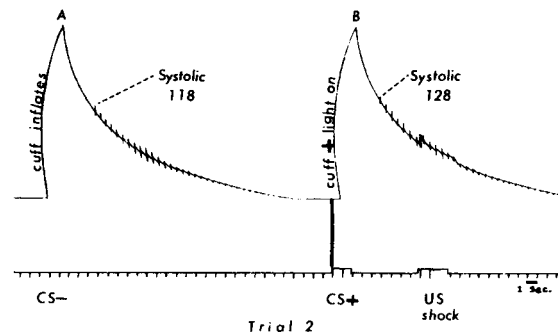


Fig. 1. Two blood pressure read-outs for 1 S. Placed in the region of the left brachial artery the cuff produced no S discomfort since it inflated to a maximal occlusion of less than 2 sec. (Letters A & B). During bleed-off the Korotkoff sounds, sensed by a cuff microphone, were transduced to low voltage pulses which activated the channel recording pen inscribing the record of systolic and diastolic sounds. The pressure values were read off the calibrated polygraph paper.

electrodes, coated with electrode paste. The E & M stimulator output pulses are applied through low impedance (250 ohms) transformer-isolator output circuitry. An automatic timer controlled the duration of the light, the shock and the 9 sec. interstimulus interval. This interval, which commenced with cuff onset, was used because its length insured the occurrence of a pressure read-out prior to shock onset.

## Results

The measure of discrimination was defined as the CS+ pressure minus the preceding single CS- pressure or minus the mean of the preceding 2 or 3 CS- pressures. With the groups combined the 2-tailed Sign test was applied to the number of trials (N) on which  $CS+ \leq CS-$ . In conditioning,  $CS+ > CS-$  (N=88),  $CS+ < CS-$  (N=59)  $p = .02$ . In reconditioning,  $CS+ > CS-$  (N=77)  $CS+ < CS-$  (N=49) and  $p = .02$ . In the two pooled phases,  $CS+ > CS-$  (N=165),  $CS+ < CS-$  (N=108) and  $p < .001$ .<sup>2</sup>

Figure 2, top (group 1) and bottom (group 2) shows that in session 1 for both groups, the CS+ curve during the shock phase rises higher than the CS- curve. For group 1, 8 of the 10 points on the CS+ curve are higher than those on the CS- curve while for group 2, the CS+, CS- separation is apparent in the latter trials of conditioning. In reconditioning, the separation of the two curves is evident in that for each group, the CS+ curve is higher on nine of the 10 trials of the phase. The 2-tailed Wilcoxon test was applied to the distribution of all the CS+ CS- differences in the separate conditioning and reconditioning phases. For group 1,  $p = .01$  and  $p = .03$  while for group 2,  $p = .04$  and  $p = .02$ .

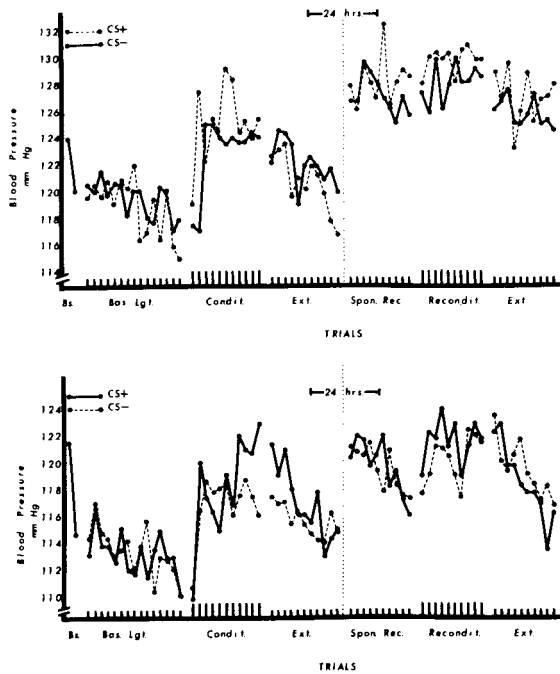


Fig. 2. Systolic blood pressure on the first and last half of Basal (BS.) phase and on every trial in each subsequent phase; Basal Light (Bas. Lgt.); Conditioning (Condit.); Extinction (Ext.); Spontaneous Recovery (Spon. Rec.); Reconditioning (Recondit.) and Extinction (Ext.). Each of the mean CS+ and CS- values in the figures is an average of all the readings. Top: Group 1: CS+ = cuff + light; CS- = cuff inflation alone. Bottom: Group 2: CS+ = cuff inflation; CS- = cuff + light.

## Discussion

The significance of the CS+, CS- differences in the two shock phases strongly suggests that conditioned discriminative control of the systolic blood pressure was obtained. However, certain aspects of the present data require further investigation. First, deviations from findings which would be expected with a discriminative conditioning procedure are seen in the first extinction phase for group 1, second extinction phase for group 2, and the overlapping of the CS+ CS- curves for group 2 in the spontaneous recovery (SR) phase.

Moreover, in the last five trials of reconditioning, both groups show a small reduction in the CS+, CS- differences which appears mainly attributable to an inexplicable rise in the pressure to the CS- stimulus.

Secondly, for 12 of the 15 Ss the combined CS+, CS- pressure in the entire SR phase was higher than in the last half of both extinction 1 ( $N=15, p < .02$ ) and the basal light phase, ( $N=15, p < .01$ ). The combined pressure level in the initial phase of day 2 does not appear to be the classical spontaneous recovery of a conditioned response since Fig. 2 shows that its magnitude is greater than that seen on most trials of the preceding session. As suggested in the data of the initial basal phase (see Fig. 2, top and bottom), in which a significant drop in blood pressure occurred between the first and last half of the trials, it may be that blood pressure was under the control of S and/or situational parameters in addition to those manipulated in the study.

Finally, it is difficult to determine the effect of a shock UCS on the systolic blood pressure independently of a cuff as a CS. Since such a determination would require that shock be delivered at a point where the pressure read-out was occurring or was about to occur, the shock would always be proximal to a cuff inflation. Although this difficulty obscures the relative contribution of the UCS, CS+ and CS- to the magnitude of the blood pressure increases seen in the present study, it does not directly bear on the fact that consistent CS+, CS- differences were obtained in the two conditioning phases.

## References

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## Notes

1. This research was supported in part by Grant No. MH 10628-01 from the National Institute of Mental Health, U. S. Department of Health, Education and Welfare, Public Health Service.
2. The N for the Sign test excluded ties ( $CS+=CS-$ ,  $N=31$ ) and trials on which readings could not be made. ( $N=11$ ).