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Post-Shock "Activation" of Operant Behavior

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D. T. Lykken and R. Meisch

When hooded rats work for food reinforcement on a VI schedule in a standard Skinner-box situation, aperiodic, brief, grid shocks (controlled by a second VI programmer independent of the bar or the food-reinforcement schedule) will decrease the average rate of pressing in proportion to the intensity (and, presumably, the frequency) of the shocks. If the experimental parameters are chosen so that the animals continue to press at a reasonable rate (e.g., at an average rate of at least 100 to 200 presses per hour), the rate during the minute or so after each shock will be higher than the rate for the corresponding interval preceding the shock.

This phenomenon, which we call "shock activation," is illustrated in Fig. 1. Four animals worked for food pellets on a one-minute VI schedule after 23 hours of food deprivation. A 0.5-second shock (60 cycle AC, about 117 volts through a 267 K-ohm series resistance) was delivered on a three-minute VI schedule consisting of equal frequencies of the following intershock intervals: 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, and 330 seconds. Bar presses were counted separately for six successive 10-second intervals, beginning 30 seconds before and ending 30 seconds after each shock. As Fig. 1 illustrates, these animals pressed at a rate of approximately 1,000 responses per hour during the half minute before the (unpredictable) shocks but increased this rate to approximately 1,500 presses per hour during the half minute following each shock.

Since the minimal interval between shocks was 30 seconds, these results might have been due to the animals' having learned that the immediate postshock period was "safe," that is, a kind of conditioned inhibition of that generalized fear response which was also responsible for the general lowering of the rate to 1,000 responses per hour from the 3,000 to 3,500 per hour characteristic of animals working with shock set at zero intensity. Therefore, the shock schedule was modified to include three, five-second intershock intervals during each one-hour daily run. The results of this change are also given in Fig. 1, which shows that, although the preshock rate decreased to about 500 presses per hour, the rate during the half minute after each shock continued to be about 500 presses higher. (The decrease in the overall rate caused by reducing the minimal intershock interval was not studied systematically and may not be a reliable finding.) In this second experiment, the recording equipment was modified so that preshock and postshock presses were not counted for those shocks preceding or following the five-second intershock intervals.

Increasing the shock intensity even slightly decreased the average pressing rate as well as the absolute amount of increase in postshock pressing. This is shown in Fig. 1 by the third curve, which gives the results for the same four animals when the source voltage was increased to 135 volts with the same five-second minimal intershock interval. Here, the rate increased from just under 400 to just over 500 presses per hour after shock.

It was clear that this "activation" of press rate following shock endured longer than the 30 seconds during which responses were tabulated in these experiments. Therefore, the apparatus was modified to count presses during six separate, successive 10-second intervals that followed every shock not followed in 60 seconds by a second shock. In order to provide a base-line rate, a seventh counter tabulated all presses except those emitted within 60 seconds following any shock, while a running time-meter recorded the total time that this counter was in action. For this third experiment, a new VI schedule for the shock was constructed to give intershock intervals of 5, 10, 20, 50, 100, 200, and 500 seconds. In this schedule, the intervals were roughly logarithmic and probably provided a more even distribution of intershock intervals relative to the animals' own subjective sense of time. The logarithmic scale also provided a greater density of short intershock intervals and thus helped ensure that the 60 seconds following shock could not be construed as "safe."

As may be seen in Fig. 2, under the above conditions, the same four animals produced an average preshock rate of about 200 presses per hour, which increased to about 350 per hour during the first 10 seconds following the shock. The press rate then decreased gradually to approximately preshock level by the sixth 10-second interval. The second curve in Fig. 2 represents the mean rates for 12 new animals run at a weaker shock intensity (source voltage of 90) on an approximately logarithmic schedule of intershock intervals but with a minimal interval of 50 seconds. (This schedule included intervals of 50, 100, 200, and 500 seconds.) The average preshock rate for this group was about 840 presses per hour, which increased to about 940 during the first 10 seconds following the shock and then decreased at a fairly smooth rate in the ensuing 50 seconds to a level just above the preshock rate.

Fig. 3 shows the mean rates for the original four animals during the 30-second periods just before and just after the shock; these are plotted separately as a function of shock intensity. For convenience, the ordinate has been laid off in logrithmic units so that these two curves represent the log of response rate as a function of shock strength, which is given in terms of source voltage in this quasi "matched impedance" shock circuit. Shock levels were determined by setting the intensity control of a standard Foringer Model shocker at 0, 5, 10, 15, 20, and 25. These settings corresponded with source voltages of 0, 45, 90, 135, 180, and 225 volts respectively, through a series resistance of 267 K-ohms. Assuming Campbell and Teghtsoonian's (1958) average rat impedances for these shock levels, viz., about 160, 75, 50, 42 and 32 K-ohms, respectively, one can estimate the actual current reaching the animals by using Ohm's Law, which gives values of 0.12, 0.26, 0.42, 0.58, and 0.75 ma, respectively.

It can be seen in Fig. 3 that the preshock response rate fell off sharply as the intensity of aperiodic brief shocks was increased. Postshock rate (mean rate during 30 seconds after the shock) also decreased, but less rapidly; the mean postshock rate was higher than the preshock rate for all shock intensitites except zero; it ranged from a source voltage of 45, which should have been about three db above threshold (Campbell and Teghtsoonian [1958]), to a source voltage of 225, which should have been about 17.5 db above threshold and which was near the maximal intensity at which the animals would continue to work for food. It is worth noting that a source voltage of 225 is still a relatively weak shock in comparison to intensities commonly used with this apparatus, i.e., it is only 25 per cent of the intensity available from the Foringer shock power supply. With aperiodic brief shocks of 300 volts or more, the animals ceased pressing altogether, and their behavior was no longer under appetitive control.

The 12 animals in the second group were trained to work for food on a one-minute VI schedule and then were run for ten days (one hour per day) with aperiodic shocks of 90 volts delivered at intervals of 50, 100, 200, and 500 seconds. On the first day, only three animals clearly increased their rates of pressing during the minute following shock, while five markedly <u>decreased</u> their pressing rates following shock. On the tenth day, nine animals showed clearly elevated postshock pressing rates and only two continued to show decreased rates after shock. A fairly typical trend during the first few days of training was a decrease in rate for almost a full minute after shock, then an initial decrease in the first 10 to 20 postshock seconds followed by an increase above preshock rates in the ensuing 40 seconds, and finally an increase above preshock rates in the first 10 postshock seconds. There was, of course, considerable day-to-day variation although several animals clearly increased postshock pressing rates during most of the 10 days of training.

During this same 10-day period, the overall percentage of increase in pressing rate during the first 30 postshock seconds ranged from -22 per cent to +93 per cent from animal to animal. As shown in Fig. 4, the four animals having the lowest postshock percentage increase (-22%, -19%, -3%, and -3%) all produced a marked increase in both pre-and postshock rates over the 10 days--from about 450 and 300 presses per hour on Day One to about 1450 and 1450 presses per hour on Day Ten. Conversely, the four animals showing the highest postshock increment (93%, 39%, 36%, and 28%) responded at about the same pre- and postshock rates throughout this period, varying about an average of 362 and 519, respectively. The lowest preshock rate for the former (low-activation) group on the tenth day was 1223 responses per hour, while the highest rate for the latter (high-activation) group was 568 responses per hour. Thus, for these animals, the inverse relationship between preshock rate and postshock rate increase seems to be clear. It is possible that the low-activation animals had higher shock thresholds or were less emotionally reactive, so that the shock level used here was simply not high enough to lower preshock rates and produce relative increases in postshock rates. However, as indicated in Fig. 4, the mean rate at the end of pretraining before shock was initiated was actually higher for these animals; they therefore showed a larger drop in average rate on the first day of shock, suggesting that they were indeed responding to that stimulus.

Another possibility is that these low-activation animals were actually hungrier than the others, although all animals were maintained at 80 per cent of their ad lib body weight and run after 23 hours of food deprivation. Nonetheless, metabolic differences might have caused some animals to have a higher drive level during the work period and hence to be less affected by nonspecific increases in drive or activation following shock. Assuming that the average rate in the presence of the aperiodic shock is a measure of the relative dominance of hunger over fear motivation, the higher pretraining rates and the increasing rates during the 10 days of shock stimulation seem to square with this idea. Unfortunately, problems of scheduling laboratory facilities made it impossible to check the prediction that these animals would show lower preshock rates and relatively higher postshock rates with either a decrease in food deprivation or an increase in shock level.

On each of the 10 days, the animals were allowed to work for food on the one-minute VI schedule for 10 minutes before the first of the aperiodic shocks, which were continued throughout the subsequent one-hour run. For the four high-activation animals, their mean rates during this hour were 21.6 per cent lower than their mean rates during the preceding shock-free 10 minutes and 37 per cent lower for the last half (five days) of training. The low-activation animals produced responses during the shocked session at rates only 0.7 per cent lower than their shock-free rates; these animals actually increased their rates by 13.9 per cent under shocked versus non-shocked conditions during the last half of training. These findings are most curious, and their signifcance obscure. Is the generalized shock situation "activating" for the latter animals, increasing their overall rate but not increasing it selectively just after shock? The available data do not provide an answer.

Conclusions

1. Brief, aperiodic, nonresponse-contingent shock will decrease the response rate of hooded rats working for food on a VI schedule. Although our data are too scanty to justify curve-fitting, it appears that response rate can be adequately described as a negative growth function of the intensity of the interpolated shocks in the range from just above threshold to a (moderate) intensity of about one milliampere when food-reinforced responding ceases.

2. Response rate increases by some 10 to 50 per cent during the first 30 seconds with this increased rate diminishing again to preshock levels within 60 to 90 seconds. This increase in postshock rate appears even when the minimal intershock interval is short (5, 10, 20 seconds) and thus cannot be attributed to, say, inhibition of the generalized fear response for a period following each shock. A more systematic study would be required to determine whether there is even a reduction in this postshock "activation" when the minimal intershock interval is shortened.

3. The transitory increase in rate of response following shock might be due to a slight increase in reinforcement probability for the first few responses after a shock. Since the shock often produces a brief (few seconds) interruption in responding, then, since food reinforcement is on a VI schedule, the first few responses following this pause would have a slightly increased probability of being reinforced. Although this

mechanism seems unlikely on various grounds, it should be ruled out by repeating these observations using a VR schedule of food reinforcement. It was not possible for us to do such a study at this time.

4. A more probable explanation of the postshock increase in response rate is that a brief and rather weak shock produces a transitory and nonspecific arousal or activation which acts like Hull's _D_ to potentiate existing behavior tendencies.

5. Animals who show no increase or decrease in postshock rate during the first few days of training tend to increase their overall rate markedly during this same period; animals whose postshock rates are clearly higher than their preshock rates early in training show no such increase in overall rate from day to day.

References

Campbell, B. A. and Teghtsoonian, R. "Electrical and behavioral effects of different types of shock stimuli on the rat." _J. comp. physiol. Psychol._, 1958, _51_, 185-192.

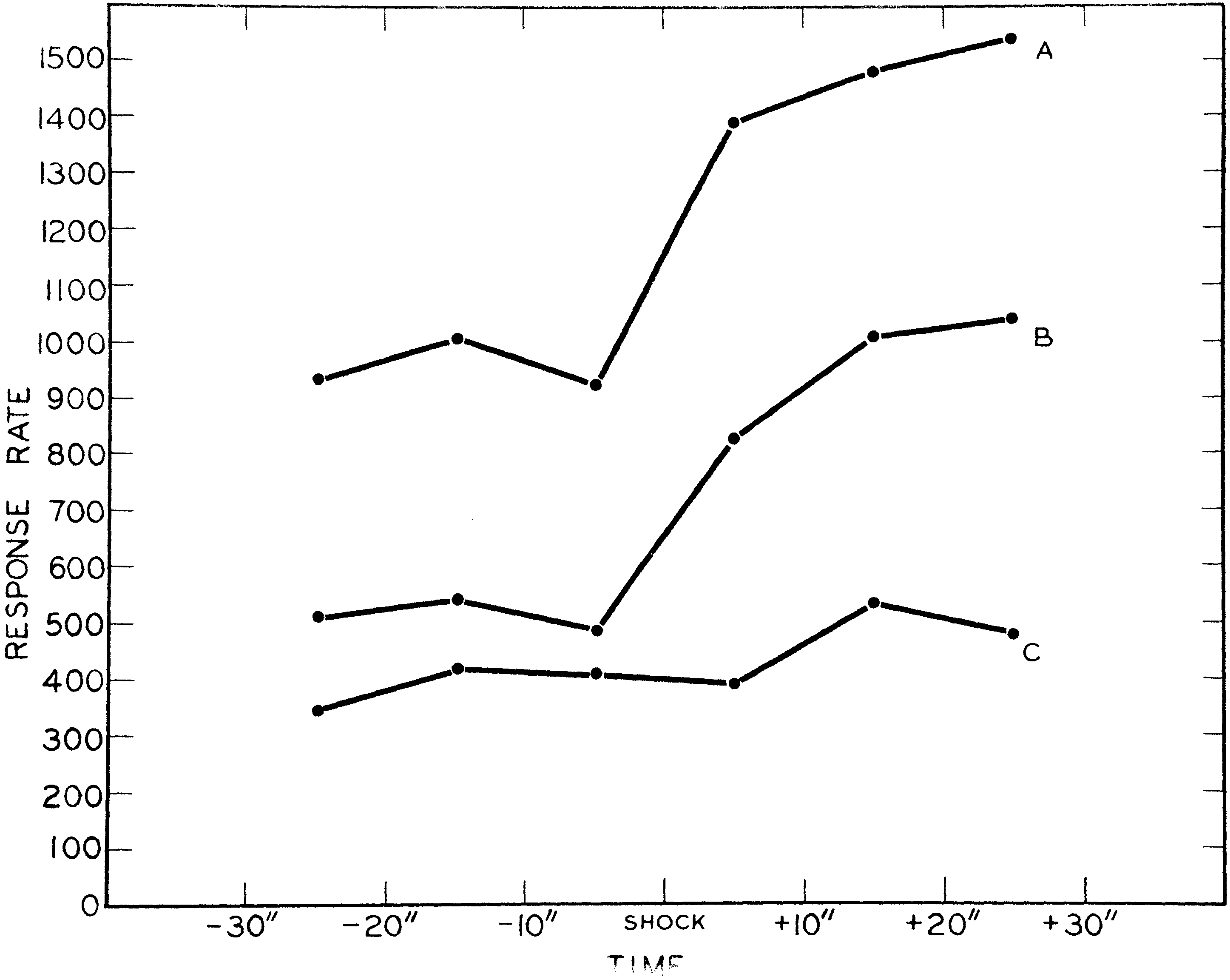
Figure Legends

Fig. 1 Response rates (presses per hour) during 30 seconds before and 30 seconds after brief non-contingent shocks. Each point represents a mean for four rats run for five daily one-hour sessions. For Curve A, the minimum interval between the 117 volt shocks was 30 seconds. Curve B resulted when this minimum interval was reduced to 5 seconds. Increasing shock to 135 volts then gave Curve C.

Fig. 2 Response rates (presses per hour) during 60 seconds after brief non-contingent shocks. Preshock rates averaged over the entire session except for 60 seconds following each shock. Each point represents five one-hour sessions. Curve A shows results for 12 rats run with a shock source of 90 volts. Curve B represents four rats run at 135 volts. Minimum intershock interval was 50 seconds for Curve A and 5 seconds for Curve B.

Fig. 3 Log of press rate as a function of shock intensity. Each point is the mean of three one-hour sessions for four rats. Rates during the 30 seconds preceding and following shock are plotted separately.

Fig. 4 Mean preshock and (0 - 30") postshock response rates for four rats who showed the highest postshock increases in rate and the four rats who showed the lowest postshock increases.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100
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300
400
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600
700
800
900
1000
1100
1200
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1500
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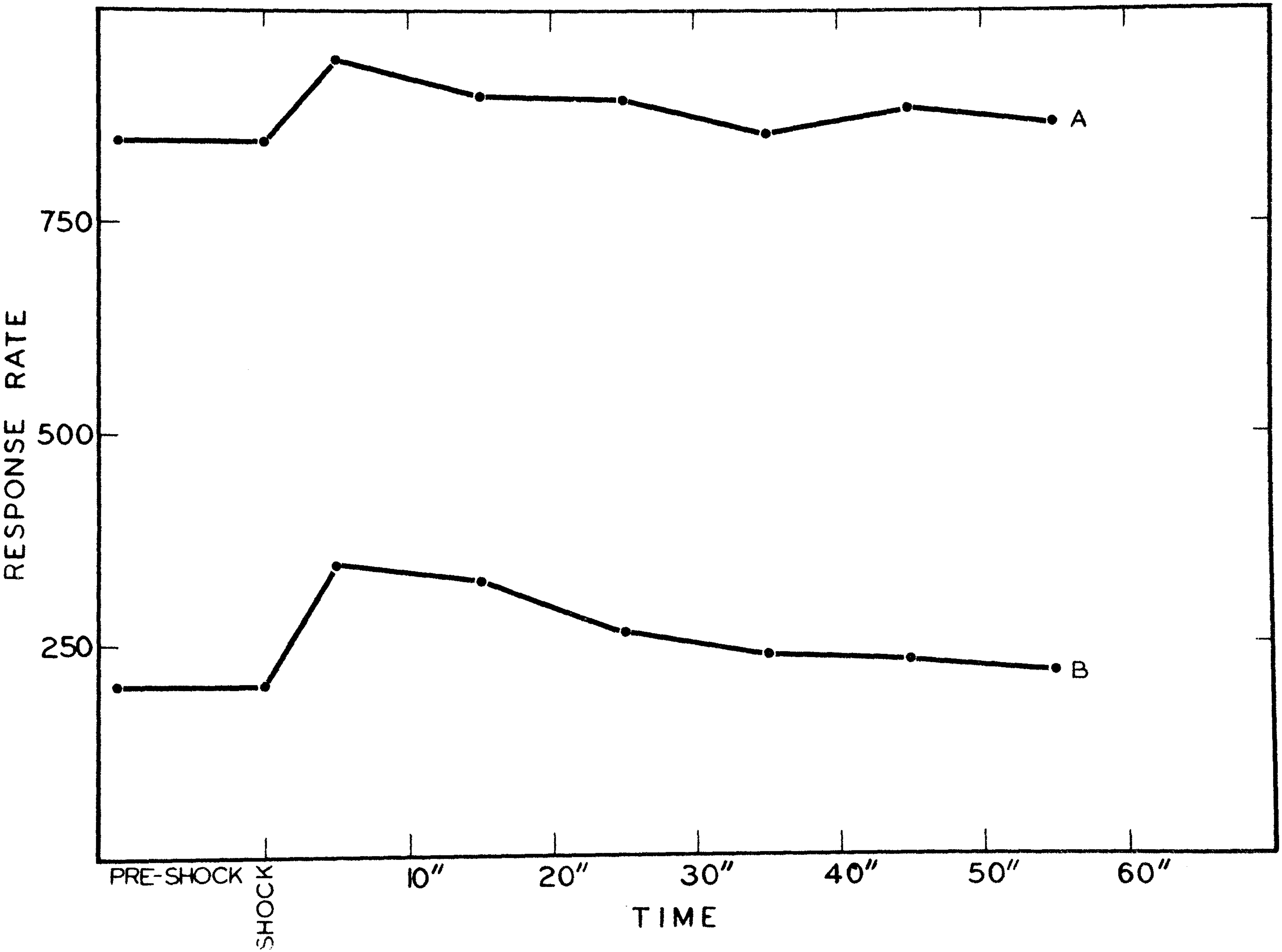
B
C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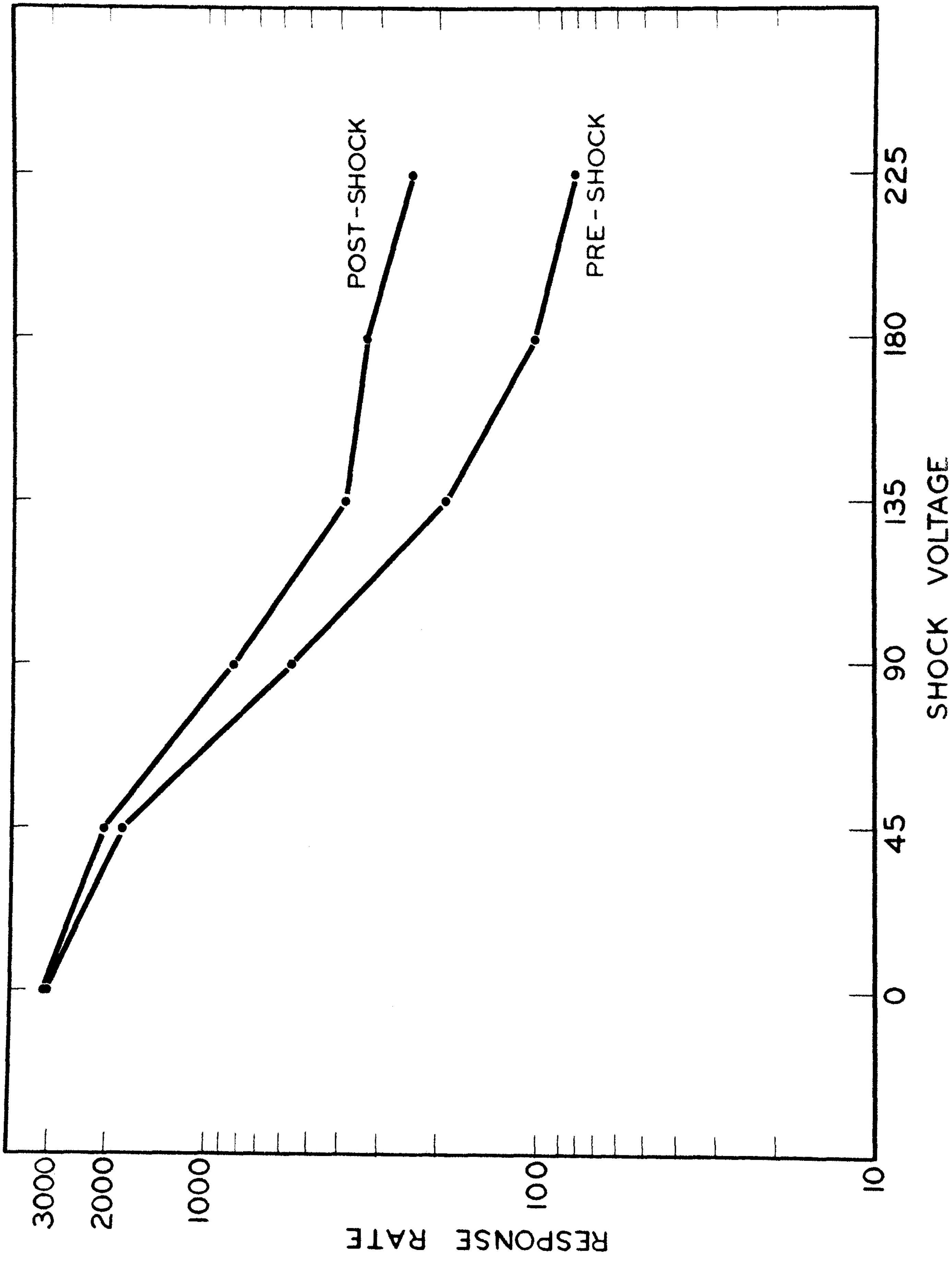
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PRE-SHOCK
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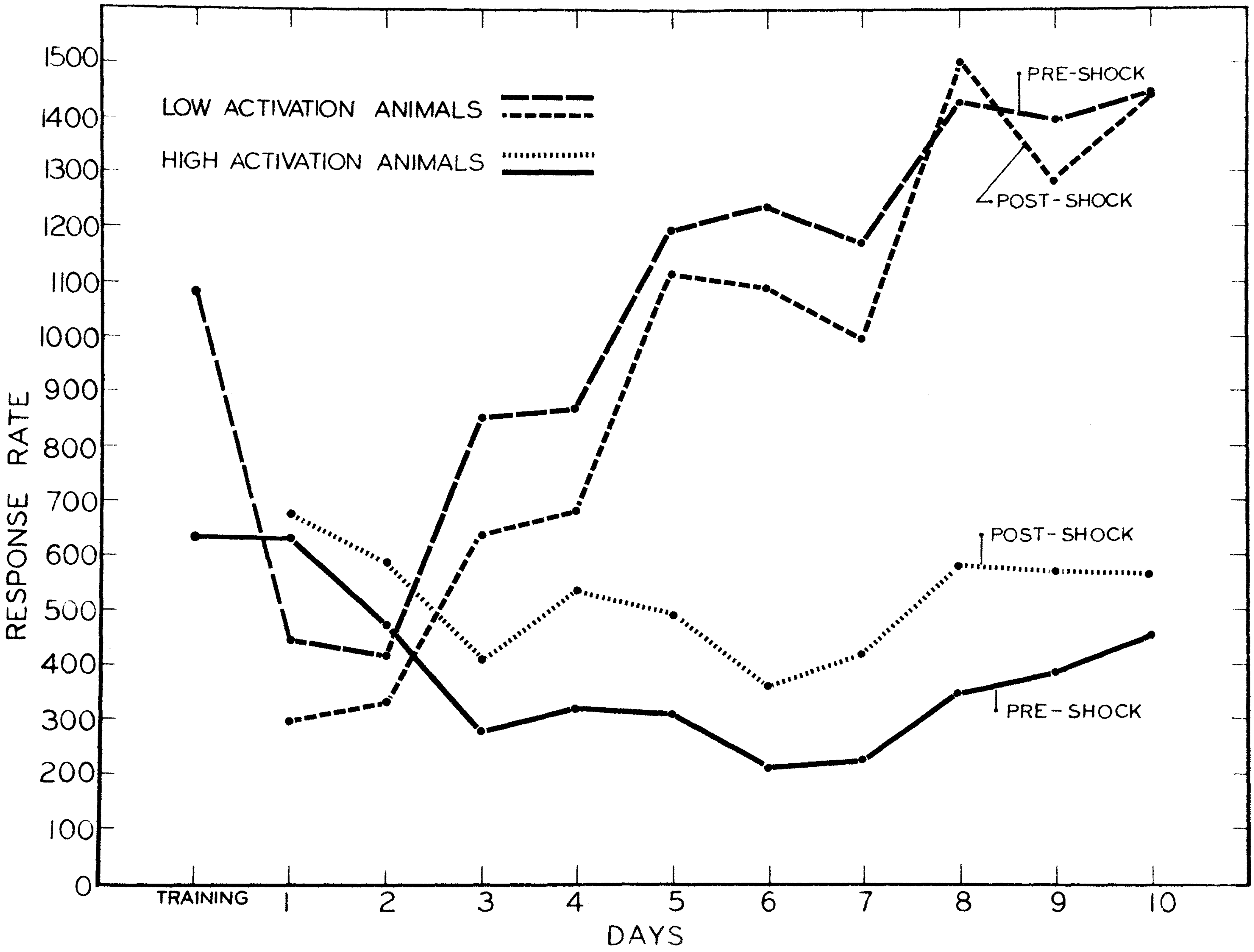
LOW ACTIVATION ANIMALS
HIGH ACTIVATION ANIMALS
PRE-SHOCK
POST-SHOCK
POST-SHOCK
PRE-SHOCK
RESPONSE RATE
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300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
TRAINING
1
2
3
4
5
6
7
8
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DAYS