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WARMUP IN FREE-OPERANT AVOIDANCE AS A FUNCTION OF THE RESPONSE-SHOCK = SHOCK-SHOCK INTERVAL

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Warmup effects, the repeated within-session transitions from ineffective to effective avoidance, were examined with rats on free-operant shock-delay procedures. The shock-shock and response-shock intervals were kept equal as they were varied. As measured by both response rates and shock rates, the magnitude of within-session change in performance was inversely related to the size of the manipulated intervals. The duration of warmup tended to decrease as the intervals were increased. This finding, that increased shock frequencies do not shorten the warmup, appears to be inconsistent with all interpretations of the warmup that have been offered to date. Late-session performances replicated general features of prior experiments, but differed with respect to details of secondary conclusions in previous reports. These differences may stem from the selection of especially proficient avoiders for previous experiments.

Key words: warmup in avoidance, free-operant avoidance, shock frequency, subject selection, lever press, rats

Soon after devising his well-known free-operant avoidance procedure based on shock delay (Sidman, 1953*a*), Sidman systematically examined the two main parameters of that procedure (Sidman, 1953*b*). Those are the response-shock interval, which is the amount of delay producible by a single response, and the shock-shock interval, which is the time between shocks if no responses intervene. He recorded the rates of responding while varying the response-shock interval, in conjunction with each of several shock-shock intervals. Subsequently, other investigators covered part of the same ground, varying the response-shock (RS) and shock-shock (SS) intervals while keeping them equal to each other (SS = RS). Using a single rat, Verhave (1959) manipulated these intervals between 15 and 50 sec. Using two rats, Herrnstein and Brady (1958) examined a set of smaller intervals, ranging from 5 to 20 sec, embedded in a multiple schedule that included appetitive behavior. Using three rats, Clark and Hull (1966) examined intervals ranging from 10 to 60 sec. All four experiments produced functions of approximately the same shape, resembling hyperbolic, or logarithmic relations between response rate and the SS = RS interval; their data gave approximately linear functions when rate was plotted against the reciprocal of the interval, at least over the ranges of intervals that were used.

While these results are reliable and useful for many purposes, they provide a very circumscribed picture of the behavior produced by free-operant avoidance procedures. Of the four studies, only the one covering the narrowest range of SS = RS intervals (Herrnstein and Brady, 1958) analyzed data from whole sessions. The other three studies omitted from analysis one-third, one-half, or two-thirds of the sessions of asymptotic performance that were chosen for data analysis. Further, Clark and Hull's experiment used preselected animals that had shown especially proficient performance. To be sure, this kind of selectivity in avoidance experiments has not been limited to studies of SS and RS intervals. Whatever avoidance variables are under examination, it is common practice to delete animals that do not avoid proficiently, and to discard the early-

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session data, even for animals that avoid well (*e.g.*, Boren and Sidman, 1957; Neffinger and Gibbon, 1975).

Deletion of data from transitional periods is justifiable, to the extent that it eliminates nonsystematic variation due to factors other than those under explicit consideration; such factors could obscure the controlling effects of the independent variables under study. However, it is not capricious variability that is eliminated by deleting the beginnings of avoidance sessions. Most animals show pronounced "warmup" effects, characterized by changes that are repeated day after day; a rat's performances early in sessions are consistently poor relative to those late in previous sessions. Sidman (1953*b*) deleted the warmup periods partly because warmup appeared to be affected by the size of the SS and RS intervals, and this could have contaminated the measures of steady-state responding that were his main focus. Clark and Hull (1966) suggested that the duration of the warmup was relatively unaffected by the SS = RS intervals, but they discarded the relevant data without doing a separate analysis. Hoffman, Fleshler, and Chorny (1961), in examining warmup effects in signalled discrete-trial avoidance, suggested that animals with substantial warmup may often be labelled (even discarded) as poor avoiders, even though their late-session performances are quite proficient. To the extent that this is true, Clark and Hull's selection of highly proficient avoiders eliminated animals with substantial warmup effects, as well as the warmup periods for animals with briefer warmup effects.

Since the warmup is a common and prominent feature of rats' performance on avoidance procedures, it is appropriate to examine it in its own right. To this end, Hineline (1978) examined the effects of intersession time on warmup. The present study examined warmup effects as response-shock and shock-shock intervals were manipulated.

METHOD

Subjects

Six male Long-Evans hooded rats, designated 1-Z, 3-B, 3-C, 3-F, 5-C, and 9-A, were obtained from Rockland Farms; three rats of the same sex and strain, designated 3-L, 3-M, and 3-O, were obtained from Blue Spruce Farms. All were approximately 120 days old when their avoidance training began. They were housed in individual home cages that provided free access to food and water.

Apparatus

The conditioning chamber was 20.3 cm wide, 23.5 cm long, and 19 cm high, with metal end walls; side walls and ceiling were of clear acrylic plastic. The floor was a grid of stainless-steel rods, 4 mm in diameter, and 1.4 cm apart, center to center. A Lehigh Valley Electronics response lever (No. 1352) was mounted at the right side of a metal wall, 5 cm above the floor; it required a force of approximately 0.15 N to produce a switch closure. The lever was electrically insulated from the wall. A relay mounted on the outside surface of the same wall provided clicks for response feedback during experimental sessions.

The conditioning chamber was enclosed in a sound- and light-resistant chest. Diffuse light was supplied during sessions by a 7.5-W 110-V bulb operated at 80 V. The chamber was fitted with an optical viewing device that permitted direct observation of the animals. White noise was supplied to the room containing the conditioning chamber.

The electromechanical control equipment was located in a separate room. Shocks of scrambled polarity, 0.4 sec duration, and 1.0 mA intensity, were delivered to grids, walls, and lever by a BRS-Foringer constant-current generator (SG-901) and scrambler (SC-901). In addition to counters giving session totals, accumulated responses and shocks were printed out every 10 min during each session. The experiments were monitored by cumulative recorders.

General Procedure

Each animal was handled 5 min per day for five days before conditioning began. The first conditioning session for each animal was 300 min long, run overnight. After a day's rest, conditioning resumed with 100-min sessions, five days per week, Monday through Friday.

Sidman's shock-delay procedure (Sidman, 1953*a*) was used throughout. For initial trainig, the shock-shock (SS) interval was 5 sec, and the response-shock (RS) interval was 20 sec. That is, in the absence of responding, a brief shock occurred every 5 sec. A response interrupted this sequence, starting a 20-sec timer. Additional responses could reset this timer, but whenever 20 sec elapsed without a response, shock was delivered and the repeating 5-sec sequence was resumed. The 5-sec SS interval was used until responding reached the point where, several times per session, the animal avoided shocks for periods of 1 min or longer, as estimated from the cumulative records. At this point, usually in the second week of training, the SS interval was changed to 20 sec. Thereafter, the RS and SS intervals were always equal.

Stability of performance was assessed on the basis of shock rates. Each week, the within-session shock rates for that week were plotted, showing, for each session, the number of shocks in the first 10 min, the second 10 min, and so on, as well as the week's median for each of these 10-min blocks. When the resulting pattern of 10 within-session blocks did not change systematically from one week to the next, as assessed by direct visual examination, the animal was exposed for one more week to the current conditions, and then the SS = RS interval was changed.

Specific Procedures and Ancillary Results

Because warmup effects sometimes change systematically over many weeks or months of conditioning (Hineline, 1966), a baseline condition of SS = RS = 20, was presented before and after each of the other values. Thus, the design can be schematized as: A B A C A D A E A, with "A" designating SS = RS = 20, and the other letters designating SS = RS intervals ranging from 5 to 60 sec. Each exposure to a given schedule lasted until stability was verified, by the procedures described above, requiring a minimum of three weeks. For three rats, 5-C, 3-M, and 9-A, Conditions B through E were to provide an ascending series of SS = RS intervals. However, Rats 5-C and 3-M began to lie on their backs during exposure to SS = RS = 5. They persisted in this, at least occasionally, even when their backs were shaved and they were returned to SS = RS = 20, so these two animals were dropped from the experiment. Rat 9-A was given the ascending series, but with the 5-sec interval omitted to reduce the likelihood of back-lying. Data from this animal are included below in summary figures.

Rats 1-Z, 3-B, 3-F, 3L, and 3-O were exposed to a decreasing series, using the full set of values. Their performances were stable on all values, so most of the data analysis deals with their behavior.

One other animal, 3-C, requires special mention. This rat was started on a decreasing series, being exposed to intervals of 60 sec and 40 sec, with 20 sec interspersed in between. There was stable performance with distinct warmup on SS = RS = 20; however, responding was not maintained on the longer SS = RS intervals. With changes from 20 to either 40 or 60 sec, the warmup became progressively longer on successive days, until by the end of the second or third week, responding had virtually ceased. At this point, 3-C was placed on SS = RS = 30 sec; responding was maintained on this procedure and on subsequent exposures to 20-sec and 10-sec intervals.

RESULTS

Figure 1 shows performance features that can be compared with the results of previously published experiments in which the SS and RS intervals were manipulated. Response rates and received-shock frequencies were computed for the final 50 min of the 100-min sessions, and median values are plotted for the final week on each SS = RS interval; the repeated exposures to SS = RS = 20 were pooled to obtain a single point at this value for each animal. In general, the functional relations were similar to those reported previously (*e.g.*, Clark and Hull, 1966). Both response rates and received-shock rates decreased monotonically as the SS = RS intervals increased, with the plots being concave upward (negative slope, but positive acceleration). When the same response rates are plotted against the inverse of the SS = RS interval—which equals the maximum shock rate that can occur on each condition—most plots were approximately linear over most of the range, turning downward at the smallest value. This finding also conforms to the general conclusions drawn by Clark and Hull. Two rats deviated from the general pattern: the performance of Rat 3-F was unstable on SS = RS = 5, and for Rat 3-C, the intervals of 40 and 60 sec failed to maintain responding. It should also be noted that Rat 9-A, which was given an increasing instead of a decreasing series of SS =

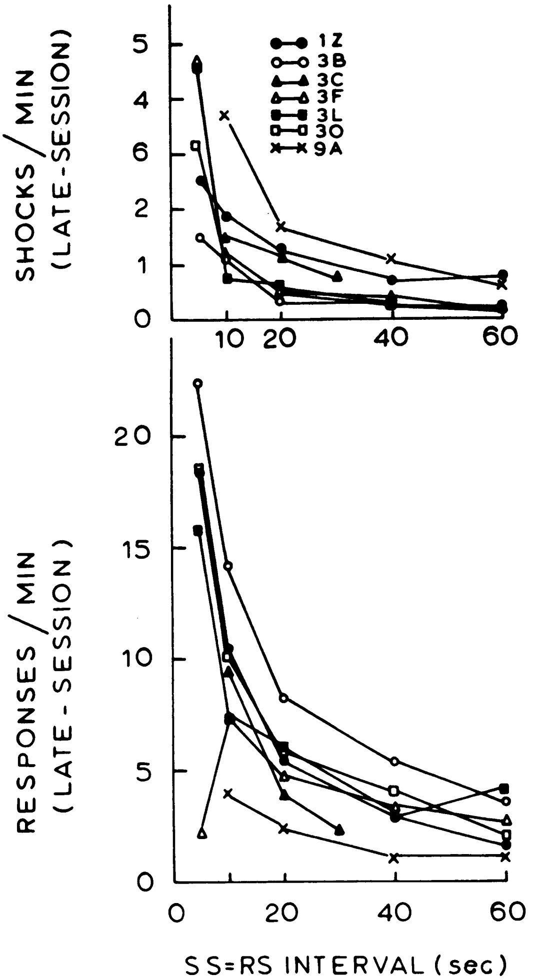

Fig. 1. Summary data showing terminal performance (response rates and received-shock rates) during the last 50 min of the session, as affected by the SS = RS intervals. Each rat is represented by a separate symbol. The data points for values of 5, 10, 40, and 60 sec represent medians based on the last five sessions on the given value. For SS = RS = 20, to which each animal was exposed several times throughout the experiment, the data point represents the mean of the medians obtained in the various exposures to this value. Values are not plotted at 40 and 60 for Rat 3-C, since responding was not maintained at these intervals.

RS intervals, performed at a less-proficient level than the others, but gave functions with the same general characteristics.

Two of Clark and Hull's minor findings were not replicated here. First, they found that the ratio of responses to shocks received was an increasing function of the RS = SS interval. This was true for only two of the animals in the present experiment (3-E and 3-O). Two rats (1-Z and 3-F) showed the opposite relationship, and the remaining rats showed no consistent relationship between these measures. Second, Clark and Hull found that the proportion of shocks avoided was an increasing function of the SS = RS interval. This was marginally true for two of the present rats (3-L and 3-O); however, 1-Z showed the inverse, and the others showed no consistent relationship of this kind. Since the various intervals were presented in systematic order (from large to small for all but 9-A, which received the opposite), one might suspect that the failure to replicate these features of the results was due to long-term shifts in performance. Further analysis indicated that this is unlikely, however. An examination of these two measures for the successive exposures to SS = RS = 20, which were interspersed throughout the experiment, revealed that in only one animal could the nonreplication of these aspects of Clark and Hull's results have resulted from a shifting baseline. Hence, with respect to asymptotic late-session performance, the primary findings reported previously were replicated here; the secondary findings were not consistently replicated.

Turning to warmup effects, the first task is one of description, and assessment of variability. Figure 2 shows cumulative records for Rat 3-F, which was the animal whose warmup effects were the most difficult to summarize. These records illustrate features that were encountered to varying degrees in other rats' performances and that are problematical for the quantifying of warmup effects. Part A of Figure 2 shows a record from the final week of exposure to each SS = RS interval. If one focuses only on response rates, warmup effects are discernible on all intervals except SS = RS = 60. The effects are revealed more clearly at all intervals by concentrations of shocks early in the sessions.

While the presence of daily transitions from higher to lower shock densities is clear, the characteristics of the transition do not appear to follow a single pattern. The five records in Part A portray variations in both the abruptness of transition to lower shock rates, and in the time from session onset until the transition begins. We shall see that the duration of warmup was indeed systematically affected by the SS = RS interval. On the other hand, the abruptness of change did not vary systemati-

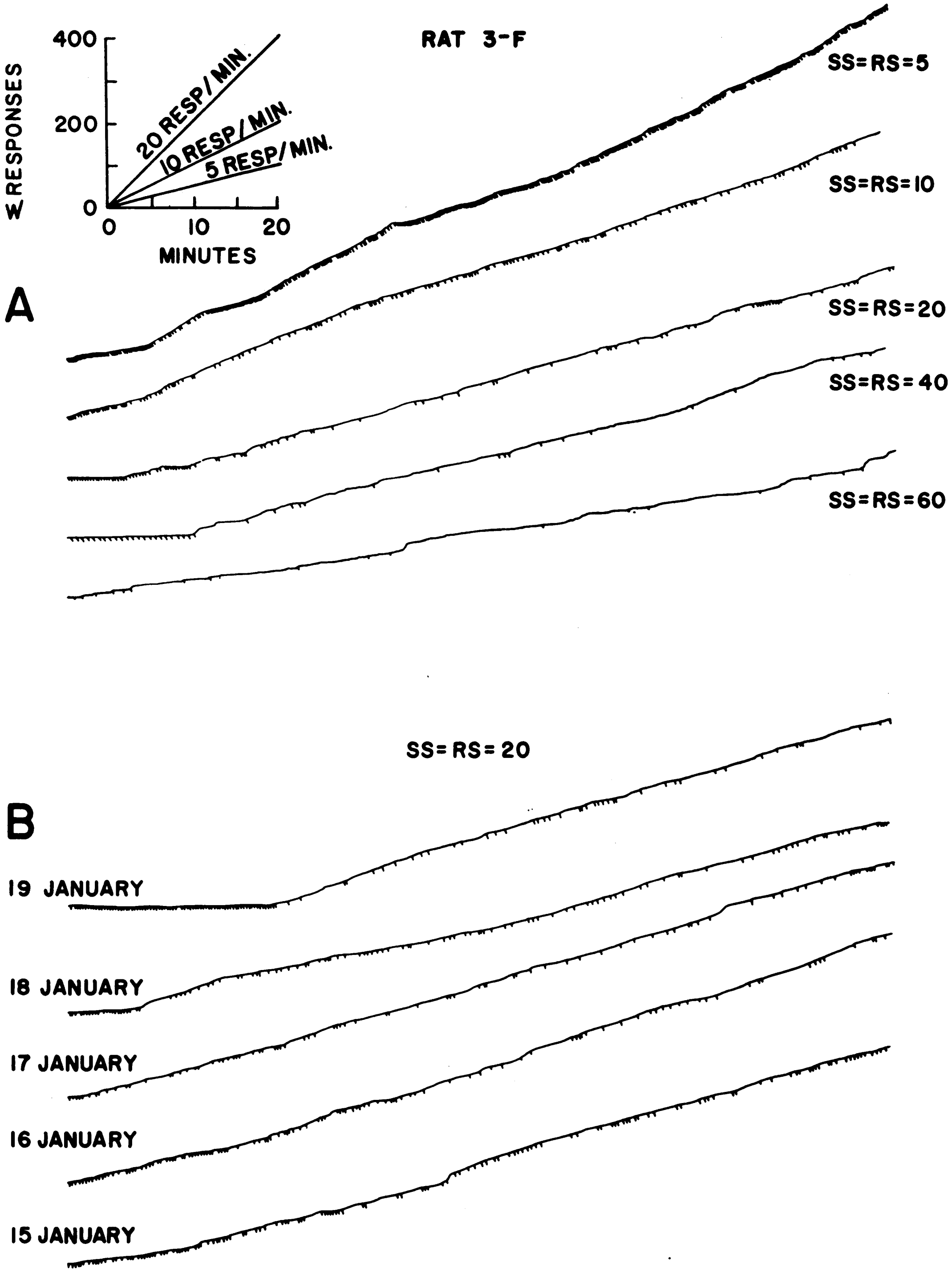

Fig. 2. Cumulative response records showing performances of Rat 3-F on five SS = RS intervals (Part A), and performances during five consecutive sessions on SS = RS = 20 (Part B). Shocks are indicated by diagonal pips on the records. In Part A, the records are presented in the order obtained, from the bottom up, with the exception of SS = RS = 20 whose exposures were distributed throughout the experiment. The specific records shown were from the final week of exposure to each condition. In each case, the record with the median number (for the week) of shocks in the first 20 min was selected.

cally with the SS = RS interval; rather, the abruptness varied unsystematically even when the interval was held constant, as illustrated by Part B of Figure 2. The abruptness of transition is of special concern, for it bears on the detection/identification of warmup effects, and on the advisability of pooling data over sessions.

The cumulative record at the top of Part B (19 January) shows a salient pattern, with its complete absence of responding at the beginning, followed by an abrupt change to proficient performance. This pattern is likely to be noticed even when one is investigating other aspects of avoidance. When, in the present experiment, I monitored the cumulative records on a daily basis to ensure that the apparatus was working properly, I came to think of this "on/off" pattern as typical for Rat 3-F. However, systematic examination revealed the pattern to be more salient than typical. Even for this animal that showed it repeatedly (*e.g.*, see also SS = RS = 40 in Part A of Figure 2), sessions with less sharply delineated warmup occurred far more frequently. Considered across animals, this was also true whether the warmup period lasted only a few minutes, or whether it lasted an hour or longer.

The more gradual change is less salient than the abrupt one. It is less likely to be detected in an experiment where warmup is not the main concern. The gradual change is also problematical for indexing the magnitude of warmup, for in performances like those of 15 and 16 January (Part B of Figure 2) it is arbitrary to state that warmup ended at any particular point. However, the fact that the gradual changes were more typical does simplify one aspect of data presentation. If abrupt transitions were the rule rather than the exception, this fact would tend to be obscured by pooling of data over sessions; variations in time to transition would lead to pooled data that indicated gradual transition. However, since sudden transitions, however salient, were the exception rather than the rule, the gradual transitions that were obtained by pooling data for the figures presented below, are reasonably accurate with respect to the characteristics they portray.

Regarding week-to-week variability: although no formal criterion was used at the time, a *post-hoc* examination indicated that a plot of median shocks per 10 min was judged as stable if the median shocks in the first 10 min did not vary more than 0.2 shocks per minute, and no more than two other 10-min intervals showed a change of more than 0.2 shocks per minute. The rule for change was also conservative, in that five additional sessions were conducted before the actual change of procedure. Those sessions supplied the data presented below, and they occurred *after* the performance had been judged stable. This mitigates against any accidental selection of particular, unrepresentative results. Finally, data are presented in the bottom row of Figure 3, showing for each rat, several replications of performance on SS = RS = 20, which provides still another assessment of stability.

Figure 3 provides a summary picture of the main features of the warmup for all seven rats. The top two rows of data plots show response rates and shock rates for successive 10-min within-session periods on each of the five SS = RS intervals. The bottom row of graphs provides comparable data for each exposure to SS = RS = 20 that intervened between the other values. These latter data show that the baseline performances of Rats 1-Z, 3-C, and 9-A were stable throughout the experiment, both in terms of overall shock rates and in terms of the patterns of within-session change. Rats 3-B and 3-F each showed a single baseline shift early in the experiment (improved performance between exposures to SS = RS = 60 and to SS = RS = 40), Rats 3-L and 3-O each showed a single baseline shift approximately midway through the experiment (after SS = RS = 40, and before SS = RS = 10). In only one of these baseline shifts (3-F) was there an appreciable change in the shape of the function.

It is clear from the top two rows of plots in Figure 3 that the magnitude of within-session performance change was drastically and systematically affected by the SS = RS interval. Warmup effects were distinctly evident in all subjects' performances on the SS = RS intervals of 20 sec or less. These warmup effects were least pronounced for SS = RS = 60, with response rates indicating no convincing warmup on this condition for Rat 3-B, and marginal evidence for warmup on this condition for Rats 3-F and 9-A. Shock rates indicated similarly marginal warmup effects for Rats 1-Z, 3-B, and 3-L, although the early-session shock rates were consistently the high-

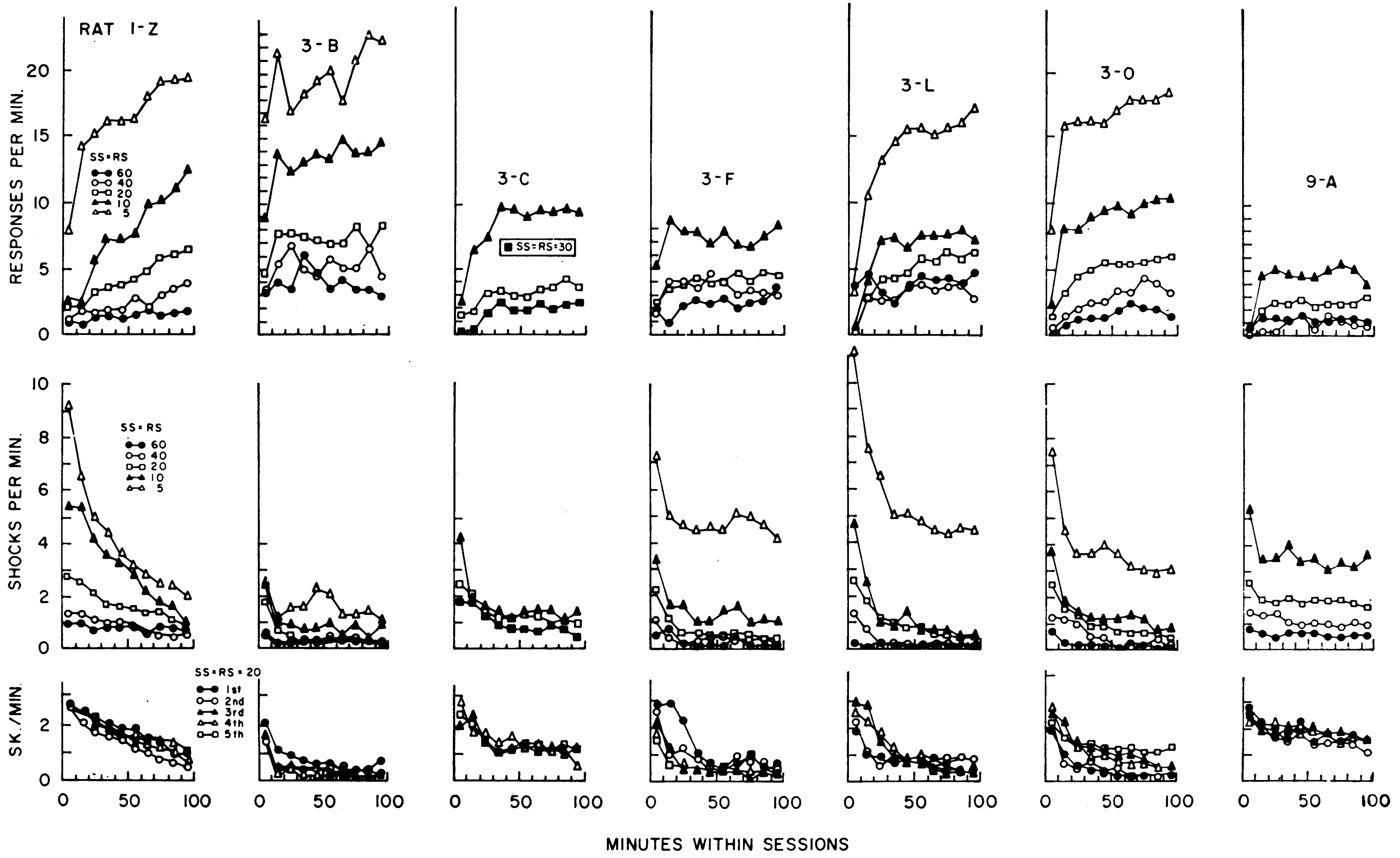

Fig. 3. Within-session changes in shock rates and response rates for all rats that were exposed to three or more SS = RS intervals. The graphs in the top row show median response rates for successive 10-min portions of the 100-min sessions for each of the SS = RS intervals presented. The graphs in the second row show comparable measures of shock rates. The bottom row shows shock rates obtained in the repeated exposures to SS = RS = 20 that were interspersed between the exposures to the other values. Median values were plotted, based on the last five sessions on each condition. The values plotted for SS = RS = 20 in the top two rows of the figure are median values pooling final weeks from the several exposures to this interval.

est for all but 1-Z. The next longest intervals, SS = RS = 40, gave marginal warmup effects for only two of the seven rats, 3-B and 9-A. The marginality of warmup at these two intervals originates as much from unimpressive late-session performances as from early-session deficits.

In several cases, the performance changes persisted throughout each 100-min session. Rat 1-Z was most consistent in this pattern, with shock rates and response rates shifting systematically throughout the sessions on all intervals except SS = RS = 60. Several other rats' performances shifted throughout the sessions, but with the greatest parts of the shifts occurring within the first 30 min. (Response rates: Rat 1-Z at 5; 3-B at 5, 10; 3-C at 10; 3-L at 5, 10, 3-O at 5, 10. Shock rates: Rat 3-C at 10; 3-L at 5, 10; 3-O at 5, 10.) In each of these cases, varying criteria for within-session stability would produce varying judgements regarding when the warmup period was completed. That is, as noted earlier with respect to cumulative records it is often arbitrary to state that warmup is over at any point during the session. Recognizing this fact, two measures of warmup duration are included in the summary measures that follow.

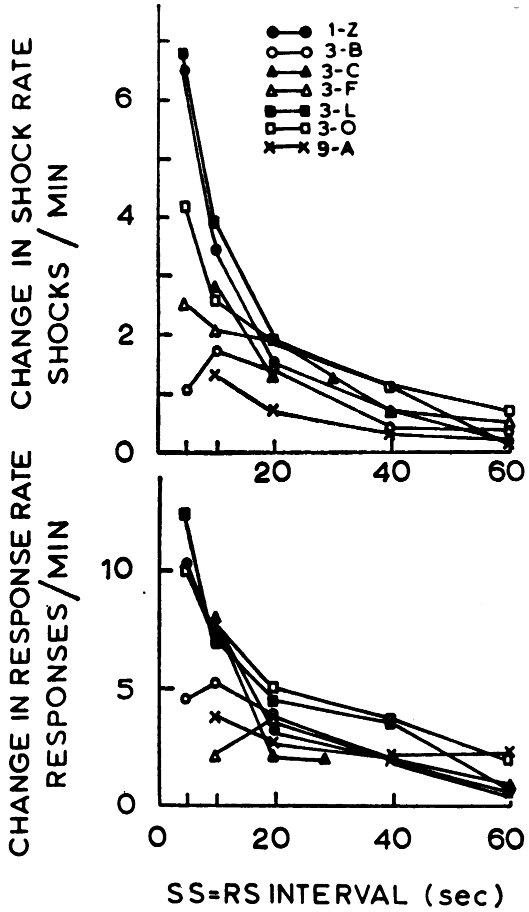

Fig. 4. Magnitudes of performance change during warmup for all animals that were exposed to three or more SS = RS values. Each data point is based on median response- and shock-rates during the final week of exposure to a given RS = SS interval; they show the difference between the shock- or response-rate in the first 10 min of the session and the comparable rate in the second half of the session. Since each animal was exposed to SS = RS = 20 several times throughout the experiment, the measures were pooled for that value, using the mean of the several medians.

Summary measures of the magnitude of performance change during warmup are presented for all animals in Figure 4. This magnitude measure was obtained by finding the difference between the shock rates or response rates in the first 10 min of the sessions, and the corresponding measures for late-session performance computed as for Figure 1. The resulting measures plotted against the SS = RS interval give functions that resemble those of Figure 1. This is not surprising, for smaller SS = RS intervals give relatively greater ranges for possible within-session change—change from high early-session shock rates, or change to high late-session response rates. Nevertheless, the results of Figure 4 were not constrained by those shown in Figure 1, so the similarity is of some interest. It should be noted in Figures 1 and 4 that for some animals, performance patterns deteriorated at small SS = RS values. Rat 3-F's responding deteriorated at SS = RS = 5. The within-session patterns for both 3-B and 3-F deteriorated at intervals of 5 and 10 min, due to fluctuations in late-session performance.

Duration of warmup can be defined as the time from a session's beginning to the point where the late-session level of performance is reached. In the present experiment, measures based on this definition were obtained by finding the 10-min interval in which a rat's performance reached or exceeded the mean level of performance for the second half of the session. The midpoint of that interval, then, indexed the duration of warmup. Figure 5 presents these measures, based on each rat's median response rates and shock rates during the final week of exposure to each condition. The top part of the figure shows the time rats re-

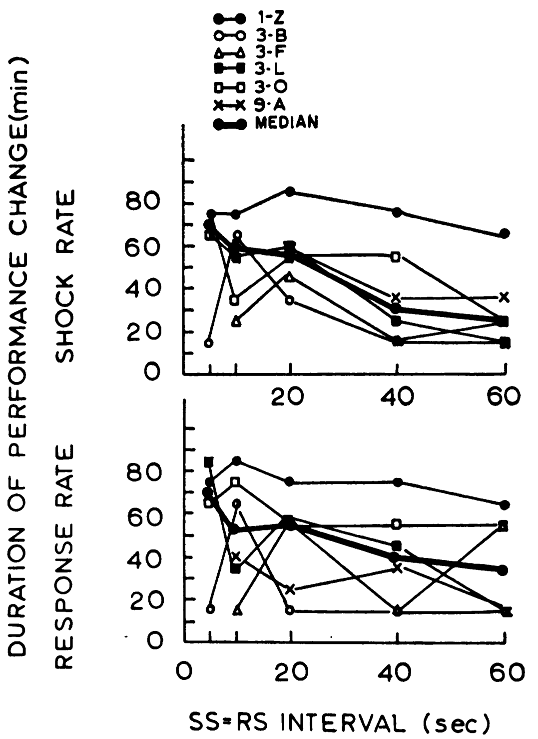

Fig. 5. Duration of within-session performance change as a function of the SS = RS interval, plotted for individual rats and also showing medians taken across subjects. The upper graph is based on shock rates. The ordinate indicates time from session onset to the middle of the 10-min interval where shock rate was less than or equal to the late-session shock rate. Late-session shock rate was defined as the mean shock rate for the final 50 min of the 100-min session. The lower graph shows time until the middle of the 10-min interval where response rate reached or exceeded the late-session level. These measures were based on median response and shock rates during the last five sessions of exposure to each SS = RS interval. Data were pooled for the repeated exposure to SS = RS = 20.

quired to produce shock rates equal to or below their mean rates for the second half. There was a tendency toward shorter durations of warmup at *longer* SS = RS intervals. The exceptions to this were 3-B and 3-F, whose late-session performances fluctuated at short SS = RS intervals, and Rat 1-Z, whose warmup usually persisted throughout the session. Even including these exceptions, medians taken across the whole group indicate a clear inverse relation between SS = RS interval and duration of warmup. The bottom part of the figure confirms all aspects of these conclusions, with duration of warmup measured as the time from the session onset until response rates equalled or exceeded the mean response rates of the second half-session.

Some of the results presented in Figure 3 suggested that while the total duration of warmup decreased with increasing SS = RS intervals, the initial parts of the change may show a different relationship. For example, at short SS = RS intervals, Rat 3-O achieved substantial performance changes in the first 20 min, even though terminal performances were not achieved until much later. Figure 6 assesses the duration of the initial part of the warmup for all animals that were exposed to four or more SS = RS intervals. Its ordinate shows elapsed time from session onset until 50% of the total performance change had occurred. This measure does indeed give a result differing from that for duration of the whole warmup. Time to the 50% criterion shows a much weaker relation to the SS = RS interval. For three of the six rats, including 3-O, the shortest times to criterion were observed at the SS = RS intervals of 5 and/or 10 sec, but be-

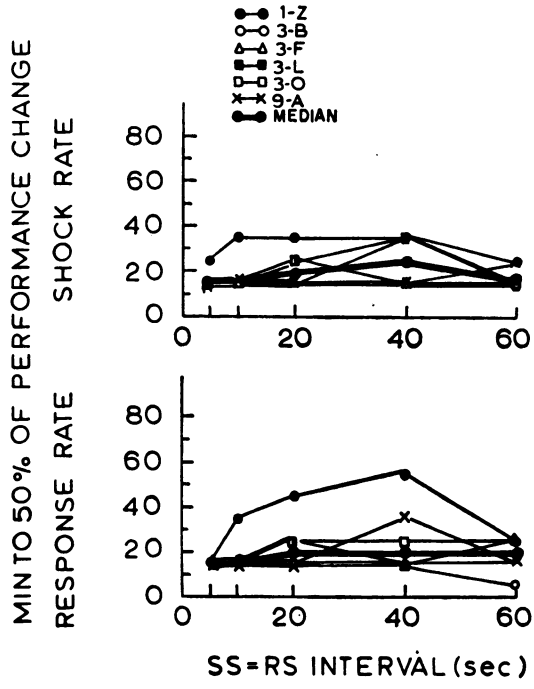

Fig. 6. Elapsed time for occurrence of 50% of within-session performance change as a function of the SS = RS interval. The methods of computation were the same as for Figure 8, except that performance levels (shock rates and response rates) midway between those of the first 10 min and the last half-session were used in place of late-session performance levels. The ordinate scale is the same as for Figure 5 to facilitate direct comparison.

yond this there was no consistent trend across the full range of intervals.

Finally, it should be noted that all animals took many more shocks during the warmup at the shorter SS = RS intervals than at the longer ones, a result that bears on interpretations of the warmup.

DISCUSSION

Regarding the general features of late-session performance, the present results are in substantial agreement with previous reports, except for a greater tendency for performances to deteriorate at extreme SS = RS values in the present study. The differences can be readily attributed to the preselection of proficient avoiders in most studies; rats that in preliminary training have produced especially low shock rates would be expected to persist more than do the less-proficient animals on procedures with marginal reinforcing consequences for responding. Clark and Hull (1966) reported no irreversible effects resulting from exposure to short SS = RS intervals. In the present work, such irreversible effects were observed when such exposures occurred relatively early in training, as indicated by the necessity for deleting two animals given early exposure to short intervals, and by the inferior performance levels shown by the third such animal (Figure 1). Also as noted above, the present animals did not consistently show relationships between SS = RS intervals and the per cent of shocks avoided or in responses emitted per shock received. All of these discrepancies should be recognized as relatively minor, but also as advising caution in extracting finely-detailed conclusions when it has been necessary to discard a substantial proportion of subjects as "non-avoiders".

The performance change that constitutes warmup in avoidance can be either gradual or sudden, but tends to occur at a characteristic rate for a given animal. The magnitude of the change is a monotonic inverse function of the SS = RS interval. The similarity of this to the function for late-session performance (Figure 1) is partly a byproduct of the fact that early-session response rates and late-session shock rates are not affected by the SS = RS interval nearly so much as are their converses, the late-session response rates and early-session shock rates. This is not surprising, given what we already knew about the effect of the SS = RS intervals on terminal performance. Nevertheless, it was not entirely predictable from late-session performances alone.

Durations of warmup effects provided especially interesting results. It appears that the rate at which performance begins to change is relatively unaffected by the SS = RS interval, as shown by Figure 6. However, the time to reach the level of late-session performance was a direct, decreasing function of the SS = RS interval in most animals. That is, more frequent shock delivery tended to produce warmup effects of longer duration when it affected the duration at all. The longer duration to reach stable levels may be related to the fact that with shorter SS = RS intervals, a greater degree of performance change is to occur.

A decreasing warmup duration with increasing SS = RS intervals has interesting implications for interpreting the warmup. All interpretations that have been proposed would predict the opposite result. For example, Hoffman, Fleshler, and Chorny (1961) proposed that the warmup reflects the buildup of motivational process. They found that the warmup was not reduced by mere confinement in the conditioning chamber before the day's routine session; however, presession shocks were sufficient to eliminate the warmup. The presession shocks were effective without the lever being present, so presession practice was not a factor. Since shock delivery *per se* was said to control the motivational state, the motivational interpretation would predict that closely spaced shocks would bring the animal through the warmup more quickly. This clearly did not occur in the present experiment.

Spear (Spear, 1973; Spear, Gordon, and Martin, 1973) suggested that the warmup reflects a "failure of memory retrieval"; that the animals require delivery of a number of shocks to reinstate the conditions under which prior learning occurred. Even if one accepts his notion of shock-induced internal cues that facilitate the retrieval of a stored repertoire, one would expect that more frequent shock delivery would result in more rapid cue-reinstatement. Clearly, this view is not supported by the present results.

The present author (Hineline, 1978) has pointed out the similarity of the warmup to habituation phenomena, suggesting that it may reflect the habituation of shock-induced or shock-elicited behavior that competes with the previously-learned avoidance response. However, this interpretation also is opposed by the present results. Parametric studies of habituation have shown that more frequent stimulation produces more rapid habituation, (Ratner, 1970; Thompson and Spencer, 1966), which in the present application would mean briefer warmup at shorter SS = RS intervals. Hence, this approach too, fails to handle the present results.

A major thrust of the present research was to reduce the need for discarding self-selected subjects as "non-avoiders", and for omitting substantial parts of conditioning sessions from analysis. Yet even here, some selection of subjects was necessary. Anomalies occurred in the development of unanticipated and unmeasured avoidance responses (back-lying) with exposures to short SS = RS intervals early in training. The variety of patterns that the warmup takes, illustrated in Figure 2, suggests that it may not be a single unitary phenomenon, although for the present we tend to treat it as such. Yet, with their limitations, the present results demonstrate some orderly features of warmup effects, and are informative regarding the generality of data obtained with more stringently preselected animals than were used here.

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