A comparison of signaled vs. unsignaled free-operant avoidance in wild and domesticated rats

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Three experiments compared the performance of domesticated hooded rats and nondomesticated black rats under signaled and unsignaled free-operant leverpress avoidance. There was no difference between groups in asymptotic shock rates under unsignaled avoidance; however, the black rats avoided much more successfully when the signal was present, while the hooded rats showed little or no improvement. When a longer signal was employed (10 vs. 5 sec), the effects were essentially the same. The black rats generally had higher response rates, and this difference was most pronounced in extinction, where the hooded rats made very few responses. The domesticated rats received a disproportionately large number of shocks early in the session (warm-up) under unsignaled avoidance, but this tendency was much less pronounced for the black rats. However, both groups showed appreciable amounts of warm-up during signalled avoidance. The findings are discussed in terms of differences in levels of activation/arousal between domesticated and nondomesticated animals.

The extensive use of domesticated rats in psychological research has aroused periodic criticisms (Beach, 1950; Kavanau, 1967; Lockard, 1968). Apparently in response to this criticism, there have recently been an increasing number of comparisons between wild and domesticated rodents, primarily involving escape and avoidance conditioning. Initial findings suggested superior performance by domesticated rodents (Boice, 1970; Powell & Morris, 1968), but most of the rats employed in these experiments were field-trapped wild animals, so the groups were vastly different in their life histories. More recent experiments, which have attempted to equate experiential factors between groups, have found no difference in shock rates between groups (Hughes & Boice, 1973; Mason & Price, 1973; Powell, 1971).

While the groups did not differ significantly in their overall shock rates, it has been observed that domesticated rats display consistent "warm-up" effects during avoidance, while nondomesticated rodents do not (Powell, 1971, 1972; Powell & Peck, 1969). Warm-up refers to a persistent tendency on the part of the subject to take a disproportionate number of shocks early in the session. All explanations of this phenomenon so far have stressed inadequate motivation as the cause (Anderson & Nakamura, 1964; Dinsmoor, 1962; Hoffman, Fleshler, & Chorny, 1961; Powell, 1972). These authors suggest that warm-up reflects the development of a motivational process based primarily upon the delivery of shocks. Wild rodents show little or no warm-up because they appear to maintain higher levels of activation or arousal in the absence of shock

than do domesticated rats. The terms "activation" and "arousal" are used here to indicate alertness and responsiveness to stimuli.

The present study was undertaken to extend the comparisons between wild and domesticated rodents to signaled free-operant avoidance situations. Previous experiments have utilized either discrete trial avoidance procedures (Hughes & Boice, 1973) or Sidman's (1953) well-known unsignaled free-operant procedure. One would clearly anticipate that most subjects would perform more successfully under signaled avoidance. This expectation would be in accordance with two-factor theories of avoidance which stress conditioned fear of the CS (the signal) as one of the primary factors which motivate avoidance responding.

EXPERIMENT I

Surprisingly, there have been few systematic comparisons of performance in any species under signaled vs. unsignaled avoidance, and although Badia, Culbertson, and Lewis (1971) state that "it has . . . been shown that both response and shock rates are lower when signals are used," they cite no support for this statement. Among the limited evidence available, Ulrich, Holz, and Azrin (1964) reported that the introduction of a warning signal preceding shocks greatly reduced the number of shocks received by the subjects. On the other hand, Logan and Boice (1968) found that the presentation of a warning signal did not result in lower shock rates, although the response distributions were altered substantially. Ayres, Benedict, Glackenmeyer, and Matthews (1974) even found that shock rates were somewhat higher during the acquisition of signaled leverpress avoidance, in comparison to an unsignaled condi-

tion. The point to be emphasized is that the effect of a warning signal upon avoidance behavior requires further experimental analysis.

Method

Subjects. Six black rats (*Rattus rattus*) and six hooded rats (Long-Evans strain) were used, with each group being composed of three members of each sex. The black rats were first-generation offspring of field-trapped adults, and had been born and raised in the laboratory. The black rats weighed 200-255 g, and the hooded rats, 250-350 g. Black rats are members of the family *Muridae* (Old World rats and mice), which also includes the Norway rat (*Rattus norvegicus*). It is generally believed that domestic rat strains were all developed from *Rattus norvegicus* stock (Barnett, 1963). All of the rats were 4 to 6 months of age and were experimentally naive at the start of the experiment. They were housed in individual cages with free access to food and water throughout the experiment.

Apparatus. A Gerbrands rat test chamber, 20.3 × 22.9 × 19.0 cm, with a single lever at the center of one end, 7.6 cm from the grid floor, was used. The test cage was enclosed in a sound-attenuated chamber. Electric shock was provided by a 100-V ac source that included 200 K ohms in series with the output and was scrambled to the grid floor of the test chamber. A 1.2 kHz tone of 85 dB was provided by a BRS-Foringer tone generator, Model AU-902. Data were recorded by digital counters and a Gerbrands cumulative recorder.

Procedure. A free-operant avoidance procedure (Sidman, 1953) was used with all rats. Under this procedure, a fixed time interval occurs between the presentation of brief electric shocks in the absence of a leverpress response (shock-shock interval), and each response postpones the next shock for a fixed period of time (response-shock interval). In the present case, shock-shock and response-shock intervals were 5 and 20 sec, respectively. The shock duration was 0.5 sec. Responses in the presence of shock did not terminate it. Experimental sessions were 2-h per day.

The black rats and the hooded rats were each divided into two groups of three animals each, with one group from each species being exposed first to unsignaled free-operant avoidance, while the other group was studied under a signaled avoidance procedure in which the tone was presented 5 sec prior to shock onset. The tone remained on until it was terminated by a re-

sponse. All rats were exposed to a shock intensity of 1.0 mA in the first session, and this was increased by an increment of 0.5 mA in each subsequent session to a maximum of 3.0 mA, where it remained for all avoidance sessions. Each avoidance procedure (phase) remained in effect for a minimum of 10 to a maximum of 20 sessions. Training was terminated within these limits whenever performance was stable over five consecutive sessions. The stability criterion was a variation in the hourly shock rate within $\pm 15\%$ of the mean rate over five consecutive sessions. The rats were then shifted to the alternative avoidance procedure and training continued until the stability criterion was again achieved. This continued through four phases so that all rats were studied for two phases each of unsignaled and signaled avoidance.

After the last avoidance phase, responding was studied for five sessions with the same avoidance condition in effect (signaled and unsignaled), but no shocks were presented (extinction). The rats were then retrained under the alternative avoidance procedure from that which had most recently prevailed, until performance again stabilized. Then extinction was studied under this condition for five sessions.

Results and Discussion

Avoidance. All of the rats learned to avoid successfully, and individual performances did not differ substantially for most of the rats between the two phases of the same condition, as shown in Figure 1. In order to make statistical comparisons between groups, the performance of each rat was calculated as the mean over the two phases under signaled (S) and unsignaled (U) avoidance, $(S_1 + S_2)/2$ vs. $(U_1 + U_2)/2$. Kruskal-Wallis analyses of variance revealed that while there was no difference in shock rates between black rats and hooded rats under unsignaled avoidance ($H = 0.025$, $df = 1$, $p < .80$) the black rats received significantly fewer shocks when the signal was present ($H = 5.770$, $df = 1$, $p < .02$). Surprisingly, there was no difference in the number of shocks received by the hooded rats under the two avoidance conditions ($T = 2$, n.s.), while the black rats received substantially fewer shocks under signaled avoidance ($T = 0$, $p < .03$, one-tailed) according to Wilcoxon signed rank tests.

An examination of the response data shows a slight overall increase for the black rats when the signal was present, as compared to a slight decrease for the hooded rats under this condition. However, none of these differences approached statistical significance. A further analysis of the response data is presented in Figure 2, which shows the percent of total responses which occurred during the 5 sec prior to shock when the signal was present, as compared to when it was absent. This shows that both groups emitted about 25% of their responses during the interval under the unsignaled condition, suggesting that responding was rather evenly distributed over time, i.e., 25% of the responses occurred during the last 25% of the response-shock interval. Animals avoiding at this level rarely experience the shock-shock interval as they respond whenever shocked.

Figure 1. The number of responses and shocks per hour for the black rats and hooded rats under signaled and unsignaled leverpress avoidance. Each data point represents the mean performance over the final five sessions during the two phases each of signaled and unsignaled avoidance.

Figure 2. The percent of the total number of responses that occurred during the 5 sec prior to shock when the tone was present (signaled) and when it was absent (unsignaled). Each data point represents the mean performance over the final five sessions under each condition.

Figure 3. The percent of shocks during the first and second 15-min intervals of 2-h sessions. Each data point represents the mean performance over the final five sessions under each condition, pooled over the two phases for each avoidance procedure.

While both groups made proportionally more responses during the signal, Wilcoxon signed rank tests indicated a significant increase for the hooded rats ($T = 0$, $p < .03$, one-tailed) but no difference for the black rats ($T = 2$, n.s.). This indicates that the signal did affect the performance of the hooded rats as well as that of the black rats, although the change in responding for the former group did not result in lower shock rates. The use of one-tailed

tests was based on the prediction that rats would respond more when the signal was present, and would receive fewer shocks under signaled avoidance.

Warm-Up effects. Warm-up effects were analyzed by determining the number of shocks which occurred during the first and second 15-min intervals of a session relative to the total number of shocks during the 2-h session. Thus, warm-up is expressed as the percent of shocks which occurred during these intervals. It has previously been shown that warm-up is seen primarily in shock rates, rather than responses (Powell, 1969, 1972), and that the effect in domesticated rats is most pronounced during the initial 15 min of a session (Powell, 1972).

Figure 3 shows that both groups received a much higher percentage of shocks early in the session under signaled avoidance in comparison to the unsignaled procedure. A Wilcoxon signed ranks test, which compared warm-up in each rat under the two procedures, showed that the percentage of shocks received during the first 15 min of a session was significantly greater under signaled avoidance ($T = 6$, $p < .01$). A Mann-Whitney U test revealed significantly less warm-up for the black rats than for the hooded rats under unsignaled avoidance ($U = 5$, $p < .05$), but additional tests which compared warm-up under the two procedures within each group of rats yielded nonsignificant results.

The mean number and proportion of shocks which each rat received during the initial 15 min of a session is presented in Table 1. This shows that all of the hooded rats received approximately the same number of shocks under each procedure, while each black rat received substantially fewer shocks under signaled avoidance during this period. Thus, the black rats reduced the number of shocks received early in the session, as well as over the entire session, when the signal was present. While four of the black rats showed increases in warm-up under signaled avoidance, two (BR-2, 6) showed slight decreases, which

Table 1
The Mean Number and Proportion of Shocks Which Occurred During the First 15 Min of a Session for Each Rat

Black Rats					Hooded Rats				
Signaled		Unsignaled		Subjects	Signaled		Unsignaled		Subjects
Mean Shocks	Proportion (%)	Mean Shocks	Proportion (%)		Mean Shocks	Proportion (%)	Mean Shocks	Proportion (%)	
BR-1	.9	21.4	4.7	BR-1	21.1	27.4	23.2	24.7	HR-1
BR-2	4.7	19.3	18.7	BR-2	28.9	16.0	23.0	19.7	HR-2
BR-3	2.5	42.4	5.8	BR-3	19.7	19.6	22.4	17.2	HR-3
BR-4	8.4	28.6	20.1	BR-4	5.8	56.9	5.0	29.8	HR-4
BR-5	5.9	56.7	20.6	BR-5	23.2	23.9	21.2	22.3	HR-5
BR-6	5.4	8.4	15.8	BR-6	24.4	32.9	24.8	24.5	HR-6
Group $\bar{X}$	4.6	29.5	14.3		20.5	29.5	19.9	23.0	

Note—The data are based upon the mean performance over the last five sessions under each procedure (signaled or unsignaled), and are averaged over the two exposures to each procedure.

Figure 4. The mean number of leverpresses for each group under signaled and unsignaled conditions over five consecutive extinction sessions.

is why the apparent difference shown in Figure 3 did not achieve statistical significance.

It has recently been suggested that warm-up is a function of the intensity-duration product (shock intensity $\times$ shock duration). That is, the disproportionality of shocks early in the session increases as the value of the intensity-duration product increases (Leander, 1973). This analysis is confounded by the fact that shock rates were a negative linear function of the intensity-duration product. Consequently, it would appear that warm-up increased as shock rates decreased in Leander's study. This relationship would also appear to exist in the present findings for the black rats, as significantly greater warm-up occurred under signaled avoidance and shock rates were much lower under this condition.

In order to examine this function more closely, Spearman rank correlation coefficients were calculated on the relationship between shock rate and amount of warm-up under the two conditions. In both cases, positive but weak correlations were obtained (signaled, $r_s = .48$; unsignaled, $r_s = .38$), neither of which was statistically significant. Considering both Leander's (1973) and the present results, however, there does appear to be a tendency for warm-up to increase as the total number of shocks which the animal receives decreases. This appears to be due in part to the way in which warm-up is computed, for disproportionality (warm-up) can be much greater when the number of shocks in a session is small compared to when this number is large.

Extinction. Figure 4 shows that the hooded rats made very few responses during extinction, while the black rats made large numbers of responses, with more responses occurring under the signaled condition in all sessions except the first.

Mann-Whitney U tests (one-tailed), which compared the groups relative to the total number of extinction responses per subject, showed significantly less responding for the hooded rats under each condition (signaled, $U = 6$, $p < .032$, unsignaled

$U = 6 < .032$). These results indicate that most hooded rats do not initiate avoidance responding until they are shocked, whereas black rats initiate and maintain responding when no shock is presented. For example, only one hooded rat (HR-4) made more than 250 total responses during the 10 extinction sessions, while only one black rat (BR-6) made less than 1,800 responses during this period. Clearly, there was little overlap between groups.

Discussion

The present findings agree with previous results which have shown that wild and domesticated rats with similar life histories achieve equivalent asymptotic shock rates under unsignaled free-operant avoidance, and that domesticated rats display greater warm-up under this procedure (Powell, 1971, 1972). The superior performance of the wild rats during signaled avoidance was unanticipated, and the failure of the hooded rats to avoid more successfully under this procedure seems almost contrainduitive. However, there is not convincing evidence that signaled avoidance produces more effective behavior than an unsignaled procedure in domesticated rats. As mentioned earlier, Logan and Boice (1968) found that hooded rats were equally successful in avoiding shock under the two procedures whether or not a signal (CS) preceded shock delivery. While Ulrich et al. (1964) reported that the introduction of a warning signal preceding shocks greatly increased the effectiveness of avoidance responding, they presented the data for only one subject to substantiate this. Prior to the introduction of the warning signal, this rat was avoiding ineffectively, and it showed marked improvement when the signal was present. However, since the experimental design did not include a return to baseline (unsignaled avoidance), it is possible that the improvement in performance was simply the result of more extended training, rather than the signal presentation. Gilbert (1971) observed that of four rats studied, two avoided about the same proportion of shocks with and without signals, while two received fewer shocks with the signals present. Most recently, Berger and Brush (1975) reported that domesticated rats performed poorly under signaled avoidance with brief signal-shock intervals comparable to those used here. The rats avoided much more effectively when longer signals were employed. These authors speculate that brief signals may induce freezing responses, which are incompatible with active avoidance (p. 238).

The motivational explanation of warm-up does not seem to be supported by the present results, at least not in a direct sense. For these results show that warm-up varies as a function of the avoidance procedure employed, and that nondomesticated rats display warm-up during signaled avoidance. The

motivation theory would appear to predict that warm-up should be reduced under signaled avoidance, since the presence of a "fear-inducing" signal would more quickly cause a heightened level of motivation, which would result, in turn, in more effective avoidance. Instead, it was found that warm-up was greater for the entire group of subjects when the signal was present. A further discussion of warm-up will be pursued at the conclusion of this report.

EXPERIMENT II

Experiment I shows that the signaled avoidance procedure had differential effects upon the performance of the two species, in comparison to unsignaled avoidance. Specifically, the black rats showed improved avoidance, responded slightly more, and increased the proportion of response during the 5 sec preceding shock. On the other hand, the hooded rats showed no improvement in avoidance, made fewer total responses, but showed a major increase in the proportion of responses during the preshock period.

The present experiment was undertaken to study the effects of a longer preaversive signal. The rationale was based in part upon the observation that the hooded rats seemed either to respond to the signal as soon as it was presented or not at all. Thus, it was reasoned that a longer signal might enhance the avoidance of the hooded rats.

Method

Subjects. Hooded rats 1, 2, and 6 and black rats 1 and 3 from Experiment I, plus black rat 30, a previously naive adult, were used.

Apparatus and procedure. The apparatus was the same as in Experiment I. All procedures were essentially the same, except that the shock-shock (S-S) interval and the tone preceding shock were 10 sec in duration. Black rat 30 was trained under unsignaled avoidance according to the same schedule followed in Experiment I. All rats were studied until performance stabilized under unsignaled, signaled and unsignaled avoidance, respectively.

Results and Discussion

Avoidance. The principal effects found in Experiment I were largely replicated here. Figure 5 shows that the hooded rats reduced shocks by only 16.4% when the signal was present, while the black rats received 63.8% fewer shocks under this condition in comparison to unsignaled avoidance. So, even though none of the differences between groups were statistically significant, according to Kruskal-Wallis analyses of variance, the fact that the black rats again showed substantially greater improvement under signaled avoidance suggests the existence of a real difference between species. The black rats again displayed only a slight increase (24.7%) in the proportion of responses during the preshock period when the tone was present, while the proportion

Figure 5. The mean number of responses and shocks per hour and the percent of responses during the 10 sec prior to shock, under the signaled and unsignaled avoidance procedures for the black rats and hooded rats. Each data point represents the mean performance over the final five sessions under each procedure.

of responses more than doubled (111.9%) for the hooded rats during this period. The black rats responded at a substantially higher rate under all conditions, and their responding showed only a slight decrease (6.8%) under signaled avoidance, while the decrease in response rate for the hooded rats was considerably greater (31.7%). When the animals were returned to the baseline condition (unsignaled avoidance), performance stabilized at approximately the same level that it had originally under this procedure.

The results of Experiments I and II show that the presentation of a warning signal has differential effects upon the responding of the two species. The hooded rats tend to wait until the signal comes on, and then respond, while the black rats make most of their responses prior to the signal. Thus, while it would appear that the signal does not gain discriminative control over the responding of black rats, the substantial decrease in shock rate under this condition belies this conclusion. This effect could occur only through an increase in the mean interresponse time, which would result in an overall distribution of responses that would avoid a larger number of shocks.

Warm-up effects. An analysis of warm-up showed effects quite similar to those found earlier. The hooded rats displayed warm-up under unsignaled avoidance, while the black rats did not, as shown in Figure 6. Warm-up was found in both species under signaled avoidance, with the hooded rats

Figure 6. The percent of shocks during the first 15 min of 2-h sessions, under unsignaled, signaled, and unsignaled avoidance procedures, respectively. Each data point represents the mean performance over the final five sessions under each procedure.

showing an increase compared to the prior condition. When the animals were returned to the baseline (unsignaled) procedure, warm-up tended to remain at higher levels than it had earlier. Thus, it becomes apparent that while warm-up differs between species, the type of avoidance procedure employed also influences this phenomenon.

EXPERIMENT III

If the difference in warm-up between black rats and hooded rats under unsignaled avoidance results from differences in initial levels of motivation (activation), then one might predict that extended avoidance sessions would result in a decrement in performance earlier in the session for the black rats than for the hooded rats. This is based on the rationale that the level of activation for the black rats is optimal for successful avoidance early in the session. However, as the number of shocks received accumulates over the session, activation continues to increase and eventually reaches a point at which performance begins to decline, i.e., the rat receives progressively more shocks over time. Because the level of activation is initially lower for the domesticated rats, a longer period of exposure to the avoidance contingency is required before activation surpasses the level that is optimal for avoidance.

Avoidance during extended sessions has rarely been studied. Boren (1960) observed clear decrements in the performance of monkeys after 4 days under unsignaled free-operant avoidance. Leander (1973) employed 6-h sessions with hooded rats, and the data do not show any decrement in performance within sessions of this length.

The present experiment was undertaken to see whether decrements would occur in the performance of wild and domesticated rats during extended avoidance sessions.

Method

Subjects. Four black rats (BR-1, 2, 3, 4) and two hooded rats (HR-1, 2), all of which had had extensive avoidance training, were used. Fewer hooded rats were used because of the already

existing data on this species under these conditions (Leander, 1973).

Apparatus and procedure. The apparatus was the same as in Experiments I and II. An unsignaled free-operant avoidance procedure was used with S-S and R-S intervals of 5 and 20 sec, respectively. All rats were studied for 15 sessions, each with a shock intensity of 3.0 mA, and then for 15 sessions with 5.0-mA shock. Experimental sessions were 4 h/day. The rationale for employing the higher shock intensity was that it should produce a larger decrement in performance according to the activation hypothesis under investigation here.

Results and Discussion

Figure 7 shows that the black rats received progressively more shocks as the session progressed, while the hooded rats displayed the opposite trend. Hooded rat 1 could not be studied under 5.0-mA shock as the animal displayed serious distress when first exposed to this intensity.

The hooded rats showed pronounced warm-up effects, receiving approximately twice as many shocks in the first hour as in the second, and then receiving slightly fewer shocks in each successive hour. The black rats, on the other hand, typically received a larger number of shocks in each successive hour of the session. The black rats also showed a greater decrement in performance over the session at the higher shock intensity. They received 58% more shocks during the fourth hour than during the first hour at 5.0 mA, as compared to only an 18% increase at 3.0 mA. The two groups differed also in that the hooded rats showed slight increases in responding during each successive hour of the session, whereas the black rats showed slight decreases. These results offer support for the hypothesis that intra-session changes in avoidance in black rats and hooded rats are the result of differences in the general level of activation of the two species.

GENERAL DISCUSSION

These experiments show that domesticated hooded rats and nondomesticated black rats avoid with equal effectiveness during unsignaled free-operant avoid-

Figure 7. The mean number of responses and shocks per hour for each hooded rat and for the four black rats as a group. Each data point represents the mean performance over the final five sessions at each shock intensity.

ance. The most surprising finding is that domesticated rats do not show significant improvements in avoidance when a signal precedes shock, whereas nondomesticated rats avoid much more successfully under this condition. As mentioned earlier, there are previous reports which show little or no improvement for domesticated rats under similar conditions (Gilbert, 1971; Logan & Boice, 1968). This finding, in conjunction with the consistent differences in warm-up between these groups under unsignaled avoidance, observed here and in previous experiments (Powell, 1971, 1972), suggest that domesticated and nondomesticated animals differ in their maintained levels of activation/arousal. This conclusion is also supported by the results of the extinction procedure, where it was found that the hooded rats made few responses under ether condition in the absence of shock. On the other hand, the black rats made large numbers of responses and generally responded more when the signal was present.

One could surmise that wild animals exhibit higher levels of arousal because this characteristic is selected for in the natural environment, whereas no similar selective pressure exists for domesticated animals. An animal in the wild that was not particularly alert, and therefore did not respond quickly or vigorously to salient environmental stimuli would often be at a disadvantage. This would seem to be most true for a species subject to heavy predation, which is true of most small rodents.

The higher level of warm-up for the species studied here under the signaled condition is currently difficult to explain. Table 1 shows that under this condition, the black rats received a higher proportion of shocks early in the session, even though the absolute number is substantially lower, in comparison to unsignaled avoidance. Thus, the higher proportion results because of an even greater improvement in avoidance during the later parts of signaled avoidance sessions. On the other hand, the hooded rats receive approximately the same number of shocks early in the session under signaled and unsignaled conditions, but the proportion is slightly greater when the signal is present. So this group also shows some improvement in later parts of these sessions. The results for the domesticated rats is easy to reconcile with the previously stated hypothesis, i.e., that the domesticated and nondomesticated animals studied here differ in maintained levels of arousal/activation. Because of their low levels of arousal early in the session, the domesticated rats are unable to respond effectively to the signal, but as activation increases they respond to the signal more effectively. In order to remain within this same frame of reference for the nondomesticated rats, one must assume that early in the session, when their level of arousal is otherwise optimal, the presentation of the signal temporarily boosts arousal to a point above the optimal

level, so that performance is temporarily disrupted. Then, as the animal adapts to the signal, its performance improves progressively and substantially over the session. This explanation is not implausible according to the Yerkes-Dodson law, but it is conjectural.

In summary, the present results show that the hooded rats and black rats studied here achieved the same rates of shock under unsignaled avoidance. This suggests that similar associative mechanisms are operating in the different species, which is impressive when one considers the vast differences in the genetics of these animals. It also speaks to the power of this avoidance procedure as a means for controlling behavior. The substantial improvement in performance for the nondomesticated rats under signaled avoidance and the reliable intrasession changes in performance (warm-up) that were observed seem to be accountable for on the basis of differences in levels of activation/arousal between domesticated and nondomesticated rats. Such differences between species would seem to exist because of the process of natural selection which operates in wild populations, but probably has little effect upon domesticated animals in the laboratory.

The present results suggest, however, that one should utilize caution in interpreting and generalizing from studies of avoidance. For, while the two species achieved equivalent rates of shock under the unsignaled condition, other aspects of their performance were substantially different, and then the addition of a signal resulted in further divergence between species in all dependent measures. Thus, while one might anticipate that the addition of a warning signal would result in greater behavioral uniformity across species, the outcome here was essentially the opposite. Of course, the present findings are by no means unique in showing that a set of conditioning procedures may interact with species-specific variables to produce behavioral outcomes which are both idiosyncratic and unanticipated (Seligman & Hager, 1972). The present findings again demonstrate that the establishment of general behavioral principles must come about through empirical, as opposed to logical or inferential, methods.

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