RUNNING-WHEEL ACTIVITY AND AVOIDANCE IN THE MONGOLIAN GERBIL¹

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In the first of two experiments, running-wheel activity and unsignaled (Sidman) avoidance were studied in gerbils and albino rats. All gerbils ran at higher rates than any of the four rats studied. Under the avoidance procedure, four rats developed effective responding; the other two performed much less successfully. While avoidance developed more slowly in the gerbils, all showed asymptotic performance as effective as the four superior rats. The rats showed a consistent warm-up effect, receiving 60% to 80% of the total shocks in the initial third of the session. The gerbils displayed no warm-up, with shocks being evenly distributed over the session. Warm-up in the rats was not related to either response rate or to how effectively the animal was avoiding. When shock was removed, extinction occurred more rapidly in the rats than the gerbils. In the second experiment, which involved two-way shuttle avoidance, gerbils and albino mice quickly acquired the response. All animals met a criterion of 90% avoidance over 80 trials.

Only a few behavioral comparisons have been made between wild and domesticated animals which are closely related on the phylogenetic scale. Powell and Morris (1968) compared albino rats and cotton rats (*Sigmodon hispidus*) under several instrumental avoidance procedures. The albino rats displayed somewhat higher response rates, but the major difference observed was that the cotton rats made few responses except to shock presentation. The albino rats made many responses in the absence of shock, and thus received a much lower number of shocks. Boice, Denny, and Evans (1967) compared wild and domesticated Norway rats in the acquisition of shuttlebox avoidance. They found no significant differences between groups, although the wild rats did begin to avoid earlier.

To provide further behavioral comparisons between wild and domesticated species, running-wheel activity, unsignaled avoidance (Sidman, 1953), and extinction were studied in Mongolian gerbils (*Meriones unguiculatus*) and in albino rats.

The gerbil is a small burrowing rodent

native to the Mongolian and Manchurian plains and deserts. It resembles the kangaroo rat of the western United States and seems to be ecologically equivalent to this species. Gerbils and rats are members of the order *Rodentia* and the sub-order *Myomorpha*. The Mongolian gerbil was introduced into the United States in 1954 by Dr. Victor Schwenker. Progeny of the original 11 pairs have become the nucleus of most research colonies now in existence. Tumblebrook Farms in Brant Lake, New York, remains the major supplier of research animals. Gerbils have recently become popular as pets, which has increased their availability. Additional information on gerbils is available in a recent article by Thiessen (1968).

The gerbil was selected for this study because it is docile and therefore easy to handle, and it can be maintained under laboratory conditions similar to those suited to rats. The cotton rats studied earlier (Powell and Morris, 1968) were highly excitable, vicious, and thus difficult to handle. They showed only minor adaptation to handling over the several months of the experiment. The cotton rats had been trapped in the wild so they differed from the albino rats in life history as well as species.

Two earlier studies, both relatively short-term, compared gerbils and albino rats. Walter, Pearl, and Rogers (1963) found that

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gerbils more quickly acquired a discriminated avoidance response, but the study extended only six days for the gerbils and four days for the albino rats. On the other hand, Wise and Parker (1967) found albino rats superior to gerbils in discriminative maze learning. This experiment was terminated after 90 trials, at which point the performance of the gerbils had clearly not reached an asymptote. Neither of the above studies reported data for individual subjects.

EXPERIMENT I

METHOD

Six adult male albino rats and four adult gerbils, two male and two female, all experimentally naive, served as subjects. The rats weighed 200 to 275 g and the gerbils 70 to 95 g. The gerbils were born and raised in the laboratory. Each was selected from a different litter. The parent stock had been obtained from a local pet store. All animals had free access to food and water in their home cages throughout the experiment.

A running wheel 16 in. (0.406 m) in diameter, with a ball-bearing axle, was used to study activity. A force of 4 g on the circumference, midway between the top and bottom of the wheel, was sufficient to overcome inertia. The wheel could be turned in either direction. Revolutions were measured in tenths through interruptions of a light beam which activated a photo cell.

A Lehigh Valley small animal test chamber Model 1316 was employed to study lever-press avoidance. Electric shock was provided by a Lehigh Valley constant current shocker Model 1531. The single lever in the test chamber required a force of 7 g to activate the micro-switch. Data were recorded from each experimental situation by digital counters and a Gerbrands cumulative recorder.

Running-wheel activity was measured for all gerbils and four rats in 1-hr daily sessions over 20 consecutive days. The time when activity was studied varied unsystematically from day to day for each animal, but each was removed from a lighted environment and placed in the dimly illuminated cubicle that housed the activity wheel. The photo beam was the only light present here, and it was focused in a plane perpendicular to the solid wooden sides of the wheel. Thus, only diffuse

light from the photo beam entered the interior of the activity wheel.

In most experimental situations, it is assumed that the operant level of lever pressing is near zero. Operant level refers to the rate of a response in the absence of any known reinforcement. Because few behavioral studies with the gerbil have been conducted, the free-operant rate of lever pressing was studied for 20 days before avoidance training for four albino rats and all of the gerbils. Experimental sessions were 1 hr per day.

The unsignaled avoidance procedure originated by Sidman (1953) was used. Under this procedure, a fixed time interval occurs between the presentation of brief electric shocks in the absence of a lever-press response (shock-shock interval), and each lever press postpones the next shock for a fixed period of time (response-shock interval). In the present case, the 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 1 hr each day.

All animals were first exposed to a shock intensity of 0.2 ma and this was increased as required to initiate effective responding. Effective responding was defined as 20 responses or more above the mean free-operant rate of lever pressing. Increments in shock intensity of 0.1 ma were made up to the 0.6-ma level, 0.2 ma increases were made from there to 1.0 ma, and 0.25-ma increases were made above that intensity. Shock intensity was increased only at the start of a session, and a particular intensity always remained in effect for one full session. Once the criterion for effective responding had been achieved, the shock intensity remained in effect until the number of shocks received increased for three consecutive sessions. Successively higher shock intensities were employed until the animal showed an increase in the mean number of shocks received over the final three sessions at three successive intensities. Also, avoidance was studied in all animals up to a minimum shock intensity of 1.50 ma.

Extinction was studied in four rats (1, 2, 4, 6) and all four gerbils through two procedures. Under Procedure I, the animal was exposed to the avoidance contingency for the first 15 min of the session. The shock apparatus was then disconnected and responding was studied for

45 min. This procedure was repeated for 10 sessions. Under Procedure II, which involved one session, shock was withdrawn after 30 min of conditioning, and responding was studied over the next 90 min. Animals studied under both extinction procedures were exposed to Procedure I first. The shock intensity employed during extinction sessions was the final one to which each animal had been exposed in the avoidance sessions.

RESULTS

Running-Wheel Activity

All gerbils ran at much higher rates than any of the rats. The results under this procedure are shown in Table 1.

Table 1

Running-wheel activity and operant rate of lever pressing.

	Albino Rats				Gerbils			
	A1	A2	A3	A4	1M	1F	2M	2F
Mean Running Rate (inches/sec)	1.2	2.0	0.6	0.3	14.3	7.5	5.3	5.1
Mean Resp/hr	2.3	0.3	0.3	1.1	185.0	16.1	13.2	48.4

Representative cumulative records of running are presented for two rats and two gerbils in Fig. 1. The records show that the gerbils ran almost continuously throughout the session, while the rats had long periods of inactivity.

Unsignaled Avoidance

The free-operant rates of lever pressing were much higher for the gerbils than for any of the four rats studied. These data are also shown in Table 1.

When the shock avoidance contingency was introduced, four of the rats (1, 4, 5, 6) responded above the mean operant rate at a slightly lower shock intensity (0.2 ma) than the gerbils. However, the complete results under the avoidance procedure, which are summarized in Fig. 2, show that the asymptotic performance of the four gerbils and four of the rats (1, 4, 5, 6) was quite comparable in terms of shocks received per hour. All of these animals reduced shock occurrences to 40 or fewer per hour. The remaining two rats performed much less successfully, consistently receiving 100 shocks or more in each session. Both of these animals displayed a consistent pattern of responding immediately to shock presentation, but made few responses in its absence. Sidman (1966) observed that most animals pass through

Fig. 1. Representative cumulative records of running for two rats and two gerbils.

this phase before they achieve more effective shock avoidance.

An analysis of warm-up effects is presented in Fig. 3. The data for Rats 2 and 3 were not included because these animals showed almost no avoidance responding in the 1-hr sessions. The individual curves are based upon performance at the final shock intensity, while the group curves summarize performance during the final three shock intensities for each animal. All rats showed a pronounced warm-up effect, while the gerbils displayed no consistent warm-up. The rats usually received 60% to 80% of the total session shocks in the initial third of the session, while the shocks the gerbils received tended to be evenly distributed over the session. The average deviations in shocks over each successive third of the session were 2%, 3%, and 1% for the gerbils, and 6%, 3%, and 4% for the rats. These statistics are based upon three consecutive sessions in which the fewest shocks were received at each of the last three shock intensities. A similar analysis of the data when the highest number of shocks were received yielded

average deviations of 5%, 4%, and 4% for the gerbils, and 4%, 1%, and 4% for the rats. These statistics indicate that the warm-up curves for animals of each species are relatively uniform.

Warm-up was slightly related to response rate in one of the rats (6). The response rate of this animal increased as the session progressed. The other rats and the gerbils showed an even distribution of responses over the session. No relationship was found between warm-up and effectiveness of avoidance responding in any of the animals studied.

The two rats (2, 3) that did not avoid effectively were each studied for three 2-hr sessions at the next-to-highest shock intensity to which each had been exposed. Each rat showed a marked decrease in the number of shocks received in the second hour as compared to the first. The mean number of shocks received over the three sessions, for the first and second hours respectively, were as follows: Rat 2 (128, 70); Rat 3 (109, 53). The marked improvement in avoidance shown by each animal during these sessions suggests that the ineffective

Fig. 2. The mean number of responses and shocks over the final three sessions at each shock intensity for each animal. The data for sessions when performance was below criterion are not presented.

Fig. 3. Individual and group curves representing the warm-up effect for the two species. The per cent of responses and shocks in each successive third of the session are presented. The individual curves are based upon data pooled over three consecutive sessions each, in which the most and fewest shocks were received at the highest shock intensity for each animal. The group curves are based upon data from the final three shock intensities for each animal.

avoidance displayed in the 1-hr sessions was principally the result of a prolonged warm-up period.

Extinction

The results under the two extinction procedures are shown in Table 2. The gerbils responded at higher rates than the rats when shock was withdrawn, even though the rats usually responded at higher rates when shock was present. This was true whether the avoidance contingency was in effect for 15 or 30 min

before extinction. Rat 2, which avoided ineffectively throughout the experiment, ceased responding almost immediately when shock was withdrawn.

Figure 4 shows extinction curves for two gerbils and two rats under each of the extinction procedures. The rats show a faster decrease in responding under both procedures, although their pre-extinction response rates were higher, except for Rat 6. During the 45-min extinction periods, the two gerbils (1M, 2M) show only a slight decline in responding.

Table 2

Responses per minute during conditioning and extinction under each procedure.

Subjects	Procedure I (10 Sess.)		Procedure II (1 Sess.)	
	Cond. (15 min)	Ext. (45 min)	Cond. (30 min)	Ext. (90 min)
Rat				
1			16.1	2.2
2	12.1	0.1	13.1	0.0
4	10.3	2.6	11.2	0.9
6	4.3	1.3		
Gerbil				
1M	6.7	5.7	6.7	2.6
1F			8.8	3.1
2M	7.7	6.0	9.6	2.3
2F			7.8	3.4

EXPERIMENT II

Boice, Boice, and Dunham (1968) found mice (*Mus musculus*) to be superior to both gerbils and kangaroo rats (*Dipolymus meriones*) in acquiring shuttle avoidance. They explain their results on the basis of differential reactivity to shock in the animals studied. While the results of the first experiment here

indicate less reactivity to shock in gerbils than albino rats, they also show that gerbils avoid at least as well as rats when shock is sufficiently aversive. This experiment was performed to study the acquisition of two-way shuttle avoidance in gerbils and albino mice. A shuttle avoidance procedure was used to see if gerbils avoided as effectively in a different situation. Mice were used rather than rats to provide an additional species comparison. Shock intensities were employed which seemed comparable in aversiveness in the two species on the basis of a preliminary study.

METHOD

The subjects were two adult gerbils, one male and one female, and four adult male albino mice (*Balb/c* strain). The mice weighed approximately 30 g each. All animals were experimentally naive and had free access to food and water in their home cages throughout the experiment. A rectangular shuttlebox constructed of 3/16 in. (4.8 mm) Plexiglas was employed. The four sides of the box were covered by heavy tape, so that light was admitted only through the top. The box was 17 in. (0.432 m) long by 4 in. (0.102 m) high by 4 in. (0.102 m) wide. Compartments 4 in. (0.102 m) by 4 in. (0.102 m) by 4 in. (0.102 m) could be formed at either end of the shuttlebox by inserting wooden gates through apertures in the top of the box. Electric shock was delivered through a grid of 1/16-in. (1.6 mm) stainless steel rods placed 1/8 in. (3.2 mm) apart. Shock was provided by a Lehigh Valley shock source, model 1579A, and was scrambled to the grid. A Precision sine-square wave generator, model E-310, was used to provide an auditory warning stimulus. The pre-shock stimulus complex consisted of three simultaneous events: (a) illumination of a 15-w bulb mounted in a movable wooden support 1 in. above the safe end of the box; (b) onset of a 5000 cps (Hz) square wave tone of approximately 85 db; and (c) withdrawal of the gate.

At the beginning of each session, the animal was placed in one end of the shuttlebox with the gate closed. The box was placed so that all of it rested on the grid except 4 in. at the end opposite to where the animal was confined. This part rested on a wooden platform that was flush with the grid surface. Each trial consisted of a presentation of the pre-shock

Fig. 4. Extinction curves for individual subjects under the two procedures. The points at zero time represent the response rates in the conditioning periods preceding shock withdrawal. Each data point represents the response rate during the preceding time period.

stimulus complex for 5 sec. If the animal did not run to the opposite end, so that all four feet were on the wooden platform, shock was presented. The shock, light, and tone continued for 10 sec or until the animal made the appropriate response. Whenever the animal made a correct response, the warning stimuli and shock, if present, were terminated. After a trial, the gate was replaced so that the animal was confined in one of the end compartments. If the animal had made an avoidance or escape response and was, therefore, resting on the wooden platform, the entire shuttlebox was shifted 4 in. (0.102 m) toward the end from which the animal had run. This had the effect of again placing the animal on the grid, while the opposite end compartment rested on the wooden platform. All animals were tested for 20 trials a day with 90 sec between trials. Training was continued to a criterion of 72 avoidances out of 80 trials over four successive days. Response latencies were timed by a Standard Electric Time Co. running-time meter.

Before the experiment, a pilot study was conducted with several non-experimental animals of each species to determine shock intensities that would reliably produce short latency running responses. Intensities of 0.30 and 0.70 ma were found to be effective for the mice and gerbils, respectively. These shock intensities were employed throughout the experiment proper. The experiment began with two control sessions for each animal. The control sessions were identical to the training sessions, except that no shock was presented.

RESULTS

All animals quickly acquired the avoidance response, requiring from eight sessions (Mouse 3) to 17 sessions (Gerbil 3M) to attain the criterion of 90% avoidance over 80 consecutive trials. These data are presented in Fig. 5. The gerbils made more spontaneous responses than the mice during the first control session, but both groups made few responses in the second session. While gerbil 3M required five sessions more than any other animal to achieve the avoidance criterion, its performance was just below this level over the final 10 sessions.

DISCUSSION

The gerbils displayed much greater activity in the running wheel and higher operant rates

of lever pressing than the albino rats. These measures agree with gross observations of general activity in the two species. It is well known that albino rats are primarily nocturnal and gerbils also have been found to be most active in the dark (Thiessen, 1968). Since all animals were studied under the same conditions, the differences in activity observed between species do not seem attributable to differences in circadian rhythms.

Introduction of the unsignaled avoidance procedure increased lever pressing above the operant level at slightly lower shock intensities for the rats than the gerbils. While the gerbils took somewhat longer to develop effective avoidance, they all reduced the mean number of shocks to approximately 30 per hr. Their asymptotic performance was very consistent between subjects. Four of the rats (1, 4, 5, 6) avoided as successfully as the gerbils, but the other two displayed a consistent pattern of responding to the shock presentation while making few responses in its absence. As a result, they never received fewer than 100 shocks in the 1-hr sessions. However, when these animals were each studied for three 2-hr sessions, they both showed a marked decrease in the number of shocks received during the second hour. This finding suggests that their poor performance was primarily the result of a prolonged warm-up period. Warm-up effects are commonly observed in avoidance conditioning. These effects are seen in a tendency by a subject to take a disproportionate number of shocks at the start of the session. The other rats also showed persistent, but less prolonged, warm-up periods. These animals consistently received 60 to 80% of the total session's shocks in the initial third of the session, while the shocks received by the gerbils tended to be evenly distributed over the sessions. Thus, the gerbils do not display a warm-up effect under unsignaled avoidance. The degree of warm-up observed in a rat was generally unrelated to either response rate or the effectiveness of the animal's responses in eliminating shocks.

The gerbils emitted more responses in extinction than the rats, even though the rats generally had higher response rates in the 15- or 30-min conditioning periods that preceded shock withdrawal. The principal difference observed was that rate of responding declined more rapidly for the rats than the gerbils under extinction. Extinction curves for the

Fig. 5. Individual learning curves for all subjects under two-way shuttle avoidance. No shock was present during the control days.

gerbils tended to decrease linearly while those for the rats were negatively decelerating.

The consistent differences in warm-up and extinction between gerbils and albino rats, as well as the differences in gross motor activity, suggest that the species differ substantially in their general level of activation or arousal. Hoffman, Fleshler, and Chorny (1961) studied the effects of a number of variables upon warm-up in albino rats. They concluded that warm-up apparently reflects the development of a motivational process resulting from the occurrence of shock itself. The absence of warm-up in gerbils, and their slower rate of extinction, suggest that a state of high arousal can be achieved and maintained in gerbils with relatively few shocks as compared to albino rats. The poor avoidance of the gerbils at low shock intensities does not seem to support this

inference. However, the greater density of hair on the paws and legs of the gerbils may partially insulate them from shock. In both of the earlier studies with gerbils which employed electric shock, the experimenters shaved the hair from the hind legs of their subjects (Walter *et al.*, 1963; Boice *et al.*, 1968). Gross observation of the animals in the test chamber revealed that the gerbils displayed a less intense reflexive response than rats to any given shock intensity.

The second experiment showed that gerbils quickly learn to avoid in a two-way shuttle avoidance situation. The avoidance behavior of two gerbils was quite comparable to four albino mice studied in the same apparatus. The present results also appear comparable with two-way shuttle avoidance in albino rats (Moyer and Korn, 1964; Theois and Dunaway,

1964). All animals met a criterion of 72 avoidances out of 80 consecutive trials. Higher shock intensities were employed with the gerbils because of observed differences in reactivity to shock in the two species.

The present results show that gerbils perform as well as albino rats in unsignaled, lever-press avoidance and as well as albino mice in signaled two-way shuttle avoidance. Thus, they afford additional generality to data secured from both species under comparable experimental procedures. The findings suggest that the Mongolian gerbil could be a useful subject in the experimental analysis of behavior. The docility and ease of maintenance of the gerbil are additional positive considerations.

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