Comparative & Physiological Psychology, 1963, 56, 539-551.
BRUSH, F. R., MYER, J. S., & PALMER, M. E. Joint effects of intertrial and intersession interval upon avoidance learning. Psychological Reports, 1964, 14, 31-37.
DENNY, M. R., & DITCHMAN, R. E. The locus of maximal "Kamin effect" in rats. Journal of Comparative & Physiological Psychology, 1962, 55, 1069-1070.
DENNY, M. R., & THOMAS, J. O. Avoidance learning and relearning as a function of shuttle box dimensions. Science, 1960, 132, 620-621.
GABRIEL, M. Effects of intersession delay and training level on avoidance extinction and intertrial behavior. Journal of Comparative & Physiological Psychology, 1968, 66, 412-416.
HAYES, W. A., & MacKINNON, R. C. Two methods of increasing response rate in free operant avoidance conditioning. Psychonomic Science, 1968, 13, 274-276.
HOFFMAN, H. S., & FLESHLER, M. A relay sequencing device for scrambling grid shock. Journal of the Experimental Analysis of Behavior, 1962, 4, 309-316.
HUGG, F. W., PIANTANIDA, T. P., & MORRIS, G. L. Free operant avoidance responding as a function of serially presented variations of UCS intensity. Psychonomic Science, 1967, 8, 111-112.
KAMIN, J. L. Retention of incompletely learned avoidance response: Some further analyses. Journal of Comparative & Physiological Psychology, 1963, 56, 713-718.
KAMIN, J. L. The retention of an incompletely learned avoidance response. Journal of Comparative & Physiological Psychology, 1957, 50, 547-560.
REYNOLDS, G. S. Behavioral contrast. Journal of the Experimental Analysis of Behavior, 1961, 4, 57-71.
REYNOLDS, G. S., & LIMPO, A. J. On some causes of behavioral contrast. Journal of the Experimental Analysis of Behavior, 1968, 11, 543-547.
SIDMAN, M. Avoidance behavior. In W. K. Honig (Ed.), *Operant behavior: Areas of research and application.* New York: Appleton-Century-Crofts, 1966. Pp. 448-498.

Exploratory behavior in response to the spatial rearrangement of familiar stimuli

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The effects of the spatial rearrangement of familiar stimuli on exploratory behavior were studied in the Mongolian gerbil. Using an open-field situation, Ss were exposed to one or a number of stimuli in a particular spatial relation to each other and to the walls of the container. A rearrangement of these stimuli (or stimulus) subsequently evoked considerably more exploration than did the control treatment. Total locomotion, the number of approaches to stimuli, and the total time spent investigating stimuli were all affected.

A considerable amount of research has been directed toward determining the role that external stimuli play in eliciting exploratory behavior. Results with rodents indicate that one of the primary determinants of exploratory behavior, either investigatory response or locomotor exploration (Berlyne, 1960), is the degree of visual novelty of the stimuli (Fowler, 1965). Recently, Corman & Shafer (1968), using an "open-field" situation, have given further confirmation of this generalization by demonstrating that rats direct an increasing amount of exploration toward that area of the open field in which change has been effected by either stimulus introduction or stimulus removal.

Shillito argues further that rodents on their home range possess a detailed knowledge of not only the general nature of stimuli, but also of the spatial organization of these objects. Yet the question of whether or not rodents are sensitive to the relational properties of stimuli has received little experimental attention, with the exception of Dember (1956) (see also Tinbergen, 1951, for a summary of invertebrate findings). Dember used a Y-maze, and his rat Ss were first exposed at the choice point to white and black alternatives. Then, on a subsequent trial, they were permitted a choice with both alternatives now identical in brightness, and the results showed that the spatially novel stimulus was reliably chosen.

Shillito (1963) has recently taken a somewhat different approach. Concerned with the behavior of rodents *(Microtus agresti)* in the natural environment, she has evidence that her Ss possess a very detailed knowledge of their home range. This familiarity is gained, she claims, by means of exploratory behavior and would certainly be highly adaptive, for instance, in finding the way back to the burrow in the shortest possible time when danger threatens.

The experiments discussed here were designed to test whether or not rodents also are sensitive to spatial cues in rather different experimental circumstances. They utilized the open-field situation, where mammalian Ss were exposed to a certain stimulus situation involving one or more objects and where the orientation of these objects was then changed to determine, in comparison with controls, the effects on exploratory activity. At least in the first experiment, we chose stimulus situations approximating the complexity of the natural environment. Furthermore, the experiments were designed so that both locomotion measures (grid crossing) and investigatory measures (approaches and total time) could be utilized as dependent variables. The Mongolian gerbil was selected as the S. This rodent species displays considerable activity in the open field and does not exhibit the wall-clinging behavior characteristic of many other rodents (Glickman & Hartz, 1964; Nauman, 1968).

METHODS

The Ss were young adult Mongolian gerbils, *Meriones unguiculatus.* They were maintained in groups of two to six in standard laboratory rodent cages, with food and water always available. Temperatures were kept around 22° C, and the animals were subjected to the natural midwinter light-dark cycle, with all tests being performed from mid to late morning. Only males were used.

The testing containers were constructed of Masonite and measured 77 x 178 cm, with a height of 57 cm. The floor of these containers was marked off into 24 units of equal size with white chalk. In introducing and removing animals from these testing chambers, a portable startbox was used (28 x 28 cm, open at the top). The Ss were placed into this box, always set at the same point in the testing apparatus, and then the box was lifted out of the arena. In capture, the animal was first confined in the smaller container and then removed. Feces were removed after the testing of each individual.

In Experiment 1, a number of stimuli were arranged in the testing container. The experiment was designed to determine whether overall activity in the open field would increase substantially with a spatial rearrangement of these same objects after a lengthy exposure to the initial configuration. The objects used included the following: six medicine bottles with rubber tubing tied to the top (height = 9 cm); four corks with a clothespin attached dorsally (height = 5 cm); five opaque jars (height = 22 cm, diam = 8 cm); one

	EXPOSURE PERIOD			TEST PERIOD	
	0-5 MIN	6-10 MIN	11-15 MIN	0-5 MIN	6-10 MIN
CONTROLS	223 6	147 4	103 4	139 6	102 6
EXPERIMENTALS	210 5	144 8	105 2	245 0	126 8

Fig. 1. Mean activity levels during an exposure period and in response to stimulus rearrangement, as compared to controls.

timing device with a cord wrapped tightly around it (10 x 19 x 10 cm); and two gas faucets of the type normally used in a chemistry laboratory (base and two outlets). During the exposure phase of the experiment, the Ss were introduced into a container for a period of 15 min. In this session, the objects were arranged in a particular orientation, the "circular arrangement." With this arrangement, the corks and medicine bottles were set up in separate circles, just off center. The faucets were set in each of two corners, the counter was placed in the center along one wall, and the jars were organized in two parallel rows at the center along the other wall of the container. Following this exposure, half of the Ss were transferred to a second similar container, with similar objects in all respects arranged in the same manner (controls). The other half (experimentals) also were moved to a second similar container, with identical objects but in a different arrangement. In this "linear arrangement," the corks and bottles were set up in two rows of five each at one end of the container, the faucets were placed together near the center, the timer was set near a corner opposite from the corks and bottles, and the jars were arranged in a row extending from the faucets to one wall. Eight Ss were tested in all, and experimentals and controls were alternated.

To insure that increased activity in the container with the objects arranged in a novel orientation was not merely due to some inherent property of the "linear arrangement," the experiment was also run in reverse. In this, the "linear arrangement" was used during the initial exposure, with half of the Ss being transferred to the novel "circular arrangement" in a different container and the other half to a container with objects arranged in a manner identical to that of the exposure period. To balance the first phase of the experiment, eight more Ss were used with this procedure.

All individuals were tested for a 10-min period. The measure quantified was the number of grids entered during the test session. Both forepaws had to be within a new square in order to score. Silent hand counters were used to measure the locomotion, and the O sat at a distance of several feet from the container, partially concealed by its high walls.

In the second experiment, a single object was employed: the gas faucet. This was placed either in the very center of the container or in one corner (18 cm from the center of object to corner and 15 cm on a perpendicular to each wall). Both the number of approaches to the test object and the total time spent with the test object were quantified during a 10-min period. A chalk line was drawn around the perimeter of the object at a distance of 3 cm, and an approach constituted the animal's moving any part of its snout beyond the line. The total time measure, consequently, was the amount of time in which the snout was within the line described.

Otherwise, the design was basically the same as in the first experiment. Sixteen Ss were presented with a container with the object in the central position for a 15-min period. Then half of these were transferred immediately to a similar container with an identical object in the same position, while the other half were transferred to a container with the object in the corner position. In the other phase of this experiment, an equal number of Ss were exposed to a container with the object in the corner and transferred to either the control or experimental condition. In all cases, the animals were introduced at a point equidistant from the two objects, and experimental and controls again were alternated in both phases of the experiment.

RESULTS AND DISCUSSION

The results for the first experiment are given in Fig. 1. It can be seen that there is a very significant (Wilcoxon test, two-tailed, $p < .01$) reduction in activity in the Ss with time during the exposure period. When the control Ss are transferred to a second container with objects arranged in the same spatial relationship, there is no substantial increase in activity over the last 5 min of exposure. In contrast, the experimental Ss transferred to a container with the objects in a new arrangement show a striking increase in activity, to a level at least as high as that of the first 5 min of the exposure period. The difference in locomotion levels between experimentals and controls for the first 5 min of the test is significant at the $p < .01$ level (Wilcoxon).

The marked drop-off in activity with time during the period of exposure is consistent with other findings in the literature and can be interpreted as a reaction to the decreasing novelty of the stimulus situation rather than to fatigue (Montgomery, 1953). The contrast in activity for experimentals and controls during the first 5 min (in particular) of the test period shows just how sensitive the gerbil is to changes of a relational kind. This change, though involving exactly the same objects, stimulates as high a level of renewed exploratory locomotion as an entirely new experimental situation. This is not altogether surprising. As stated, a detailed knowledge of the orientation of objects in the natural home range of a small mammal would be at least as important as the knowledge of the objects themselves, and locomotor exploration is the obvious means of obtaining such information.

	APPROACHES		INVESTIGATING TIME (SEC)	
	0-5 MIN	6-10 MIN	0-5 MIN	6-10 MIN
CONTROLS	7 4	5 6	19 9	13 9
EXPERIMENTALS	13 0	7 1	30 2	19 8

Fig. 2. The response to a change in position of a single stimulus, as compared to controls.

The results for the second experiment are listed in Fig. 2. Concentrating again on the first 5 min of the test period, it can be seen that the object in the novel orientation is approached more frequently than is that in the control position. Also, more total time is spent with it. These differences are both significant at the $p < .01$ level (Wilcoxon). This result further underlines the fact that a rodent is sensitive to change in the spatial orientation of familiar objects, even when the position of a single object is involved.

REFERENCES

BERLYNE, D. E. *Conflict, arousal, and curiosity.* New York: McGraw-Hill, 1960.

CORMAN, C. D., & SHAFER, J. N. Open-field activity and exploratory behavior. Psychonomic Science, 1968, 13, 55-56.

DEMBER, W. N. Response by the rat to environmental change. Journal of Comparative & Physiological Psychology, 1956, 49, 93-95.

FOWLER, H. *Curiosity and exploratory behavior.* New York: Macmillan, 1965.

GLICKMAN, S. E., & HARTZ, K. E. Exploratory behavior in several species of rodents. Journal of Comparative & Physiological Psychology, 1964, 58, 101-104.

MONTGOMERY, K. C. Exploratory behavior as a function of "similarity" of stimulus situations. Journal of Comparative & Physiological Psychology, 1953, 46, 129-133.

NAUMAN, D. J. Open field behavior of the Mongolian gerbil. Psychonomic Science, 1968, 10, 163-164.

SHILLITO, E. E. Exploratory behavior in the short-tailed vole. Behaviour, 1963, 21, 145-154.

TINBERGEN, N. *The study of instinct.* Oxford: Clarendon Press, 1951.