Strain differences among rats initiating exploration of differing environments*

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Latencies for emerging from the home cage were obtained in familiar and in strange surroundings for 557 rats from 12 inbred strains: ACI, A990 A35322, F344, INR, IR, MNR, MNR-a, MR, TS1, TS3, WAG. Significant strain effects, condition effects, and genetic-environmental interaction were found.

For those who are experienced users of laboratory rats, one of the most familiar of laboratory events is the popping up of heads and "inquisitive" sniffing when a cage is opened. This is probably the most salient natural behavioral phenomenon in the tame species. This and closely associated behavior largely determine the subjective reactions, preferences, and dislikes of animal workers for particular lines or individual animals.

The very first systematic psychological research on the rat included naturalistic observation of "curiosity" and "timidity" in the maintenance environment (Small, 1899, 1900). Small assumed that these terms represented independent behavioral "traits," the former being "intellectual" and the latter, "emotional." With factor analysis, a number of measures of response to novel stimuli in and out of the home cage, and Hall's reactive and nonreactive rats, Billingslea (1940, 1941, 1942) derived three factors: "emotionality," "freezing," and "timidity." For Billingslea, the exploratory behavior labeled "curiosity" by Small was subsumed under "emotionality," along with response inhibition to strange stimuli. Thus, of the two lines of research which considered the response to novel stimuli by laboratory rats in their natural environment, one regarded "curiosity" as simply an aspect of "emotionality," while the other considered these independent phenomena. Further research has not been carried out with the home cage behavior, and studies in experimentally contrived situations have yet to resolve the relationship of "curiosity" and "emotionality" (Barnett, 1963).

The present study provides data on the genetic variability of initial

response to exploration evoking conditions of differing degrees of novelty.

METHOD

The Ss were 557 rats from 12 inbred strains: ACI, black, agouti, Irish; A990, black, agouti, hooded; A35322, black, nonagouti, hooded; F344, albino, nonagouti, hooded; INR, black, nonagouti, hooded; IR, dilute, nonagouti, hooded; MNR, albino, agouti, hooded; MNR-a, albino, nonagouti, hooded; MR, albino, nonagouti, hooded; TS1, black, agouti, Irish; TS3, black, nonagouti, WAG, albino, agouti, hooded. The preceding lines are sometimes referred to in the literature by the following synonyms, respectively: AxC9935, August 990, August 35322, Fischer 344, Iowa Nonreactive or Hall Nonreactive, Iowa Reactive or Walker, Maudsley Nonreactive, Maudsley Nonreactive a subline, Maudsley Reactive, Tryon Maze Bright, Tryon Maze Dull, Wistar Albino. The INR, IR, TS1, and TS3 lines were derived by selective breeding and maintained for many years by partial inbreeding. More recently, they have been maintained by full sib mating. Animals in this study from these four strains had been inbred 8 or more generations. Ss from the remaining lines were inbred a minimum of 20 generations. More detailed information on the strains and their maintenance has been reported elsewhere (Harrington, 1968). There were 23 ± 3 Ss of each sex within each strain.

Animals were placed in individual Wahmann LC 75-A cages at 45-52 days of age and maintained in primary animal colony space, i.e., open to maintenance and experimental personnel. One week later, the cage was opened 4 in., and the time until the animal raised its head to a point where the eyes were above the top of the cage was recorded. The cage was closed and transported to an isolated room, where it was placed in the center of a white .20-mL-luminance open field. The cage was opened 4 in., and the head raising time recorded.

RESULTS AND DISCUSSION

By Tukey's procedure, data were additive for an analysis of variance ($p > .70$), and the standard deviation within cells therefore was estimated from the pooled error variances as 17.19.

An unweighted means analysis of variance showed marked strain differences ($F = 17.7$, $df = 11/533$, $p < .001$) and some sex difference ($F = 7.3$, $df = 1/11$, $p < .01$). The two test conditions showed a significant interaction with genotype ($F = 3.2$, $df = 11/533$, $p < .001$). A significant interaction normally vitiates a test of main effects with unequal cell frequencies. However, the average of differences in cell frequencies was less than .10, there were no additivity problems, and the formally calculated F ratios were far beyond the significance test levels employed. In short, though no exact test was available, it was self-evident that differences between test conditions were substantial and significant. Interactions with sex were clearly nonexistent.

The means for each sex within strain in Table 1 show the pattern or lack of pattern implied by the analysis of variance. While, overall, the strange environment of an open field evoked a more rapid emergence response than did the familiar animal quarters, the converse was true for some strains. No obvious consistent association between these behaviors and known emotional characteristics of the strains was apparent. Nor is the general tendency to emerge more rapidly in the open field consistent with viewing exploration as essentially an aspect of emotionality. By Billingslea's factors, one would expect diametrically opposed results, since a novel environment should produce response inhibition proportional to "emotionality," together with "caution" proportional to "timidity."

Table 1
Parameters of Strain Differences in Latencies of Emergence from Home Cage (Latencies in Seconds, SD = 17.19)

Strain	Environment			
	Familiar		Novel	
	Male	Female	Male	Female
ACI	217	182	230	189
A990	159	135	163	135
A35322	107	85	142	103
F344	207	161	160	142
INR	68	47	47	29
IR	244	194	186	114
MNR	174	202	203	215
MNR-a	164	171	166	165
MR	201	233	215	157
TS1	203	144	156	117
TS3	111	128	68	63
WAG	116	126	62	93

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These data are more consistent with the view of exploration or stimulus seeking as a potent independent variable in behavior. However, it is not possible to judge from these data whether the genetic-environment interaction represented a genetic variation in a general factor of response to novel stimuli or whether it reflects specificity of genetic effects to the specific environment in which it is expressed.

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Behavioral contrast following gradual changes in schedule*

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The multiple schedule on which pigeons were reinforced was shifted from one value to another by a series of gradual steps. While reinforcement frequency was held constant in the presence of one stimulus, that in the presence of an alternated stimulus was gradually decreased for two of the pigeons and gradually increased for the third pigeon. Behavioral contrast occurred in each case. The performance of these pigeons on the terminal schedule did not appear to differ in any important respect from that of pigeons shifted directly from a baseline schedule to the terminal schedule.

Behavioral contrast occurs as a change in response rate in the presence of a stimulus following a change in schedule in the presence of a successively alternated stimulus. This form of interaction has been demonstrated reliably under a variety of procedures involving sudden discrete changes in schedule. The question arises as to what extent behavioral contrast depends upon a change between schedules, as opposed to the independent properties of the schedule in effect before and after this change. If the nature of the change as such is relatively unimportant, it should make little difference to the final performance how the change

between schedules is carried out. The present experiment investigated whether or not the production of behavioral contrast was disrupted by gradual, step-by-step changes in reinforcement schedule.

SUBJECTS AND APPARATUS

Three homing pigeons, maintained at 80% of their free-feeding body weights, were given daily sessions in a single-key operant chamber. The key was transilluminated with red or green light, and pecks on it having more than 15 g of force (.147 N) were recorded on counters and a cumulative recorder. Reinforcement consisted of 2.5-sec access to grain from a feeder mounted below the key. During reinforcement a magazine light was on and the key light was off. The experimental procedure was controlled automatically by electromechanical circuitry.

PROCEDURE

During successive 3-min periods, the key was alternately illuminated with red and green light. Thus, each stimulus occupied 30 min per hour session. Initially, 10 reinforcements per session were scheduled at variable intervals in the presence of each stimulus (multiple VI 3 min VI 3 min). Training under this schedule was continued until responding was judged to be sufficiently stable to provide a baseline. At this point, small progressive changes in reinforcement frequency in the presence of the red stimulus were made, while that in the presence of the green stimulus remained constant throughout.

In the case of Pigeon 026, reinforcement frequency in red was decreased by an average of .5 of a reinforcement every six sessions until extinction was in effect in the terminal schedule. Since there was no satisfactory way of presenting a half reinforcement, this was achieved, on the average, by varying the number of reinforcements by one on successive sessions. Thus, during the first six sessions following baseline training, the requirement of 9.5 reinforcements was met by arranging 10 reinforcements on odd-numbered sessions and 9 reinforcements on even-numbered sessions. The 20th change in reinforcement frequency following 114 sessions introduced the terminal schedule (VI 3 min Ext). Training was continued under this schedule for 36 sessions.

For Pigeon 15, reinforcement frequency in the presence of the red stimulus was decreased by one reinforcement per session every four sessions. Eight such changes in reinforcement frequency were made, so that the terminal schedule arranged four reinforcements per hour in red, .167 of total reinforcements under the multiple schedule. Training with this schedule (multiple VI 3 min VI 15 min) was continued for 14 sessions. For Pigeon 21, reinforcement frequency in red was increased eight times, every four sessions. The magnitude of each of these increments matched that of the corresponding decrements employed with Pigeon 15 in terms of relative frequency of reinforcement (the proportion of total reinforcements occurring in red). Thus, the terminal schedule for Pigeon 21 arranged 50 reinforcements in red, .833 of total reinforcements under the multiple schedule. Training with this schedule (multiple VI 3 min VI 6 min) was continued for 16 sessions. In this way, the terminal schedules for these two pigeons provided relative reinforcement frequencies in red equidistant from that under the baseline schedule (.5).

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