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BEHAVIORAL CHARACTERISTICS ASSOCIATED WITH THE RAT-VIRUS-INDUCED 'HAMSTER MONGOLISM' SYNDROME*

THOMAS K. LANDAUER, LAWRENCE KILHAM and HENRY A. BUCHTEL†
Psychological Laboratory, Dartmouth College, Hanover, New Hampshire

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KILHAM[1] found that hamsters inoculated intracerebrally (i.c.) with sub-lethal doses of rat virus (RV) during the first few weeks of life developed a number of abnormalities. The symptoms produced by the virus, which was originally isolated from rats bearing spontaneous or transplantable tumors, included stunted growth, malformed teeth,[2] broadened facial bones, and protrusions of the eyes and tongue. The affected hamsters are somewhat 'mongoloid' in appearance (see Fig. 1). TOOLAN[3] had previously reported similar abnormalities resulting from inoculation of hamsters at birth with cell-free filtrates of human tumor cells as well as certain tissues derived from human beings and rats carrying spontaneous cancers. The syndrome has been described previously as 'hamster mongolism'.[2,7] This syndrome is to be distinguished from other abnormalities which are produced in hamsters by the same virus when inoculation occurs at developmentally different times. The use of the term 'mongolism' should not be interpreted to imply any relation other than a superficial resemblance to the human syndrome of the same name.‡

We thought it of interest to investigate the behavioral characteristics of hamsters afflicted with this syndrome. We have carried out a series of experiments in which hamsters with virus-induced 'mongolism' have been compared with normal hamsters on several standard behavioral tests.

In the first experiment, differences in learning curves for shuttle-box avoidance learning were found, suggesting that affected hamsters were slow learners as compared to normal controls. However, further avoidance conditioning experiments found that this difference, while replicable, is highly variable. In two experiments a similar rate difference was found, in a third no rate difference appeared, and the overall performance level of the affected

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† The authors, in the order listed, are now at Stanford University, Dartmouth Medical College, and McGill University.

‡ We wish to emphasize that we do not claim that the pathological state studied here is the same as Down's syndrome. While the term 'mongolism' seems to us to be a good descriptive title for the hamster disease, by analogy with the human syndrome of the same name, the question of whether the hamster disease resembles this, or any other human disease, in any aspect of its etiology, is completely open at this time.

animals was higher than that of the normals. Since avoidance behavior may reflect an emotionality component in addition to purely 'intellectual' factors, an attempt was made to separate 'intelligence' and 'emotionality'. A group of 'mongoloid' and normal control animals which had been previously tested in the shuttle-box avoidance were subsequently tested in both the Hebb–Williams maze and an open field test. 'Mongoloid' *S*s were inferior learners in the Hebb–Williams maze, and were more active in the open field test.

We report here four avoidance conditioning experiments and data obtained in the Hebb–Williams maze and open field test on animals from the last of these avoidance experiments. A number of smaller exploratory studies utilizing shuttle-box and passive avoidance tasks will not be reported.

EXPERIMENT I

Method

Fourteen experimental hamsters were inoculated (i.c.) on the sixth day of life with 0·03 ml of 1:10 dilution of RV, which had been passed at least 40 times in hamsters (i.c.). All developed the above-mentioned abnormalities, although severity of symptoms varied. Fourteen control litter-mates were inoculated in an identical manner with normal tissue culture fluid; none showed abnormalities.

The apparatus was a Mowrer–Miller-type shuttle-box, with grid and internal dimensions adjusted to the demands of hamsters (and dwarf hamsters). Inside dimensions were 19 in. L × 6 in. W × 5½ in. D, with longitudinal ⅛ in. brass grids spaced ¼ in. apart. The conditioned stimulus (CS) was provided by a door-buzzer on the rear of the box. The unconditioned stimulus (US) was a 0·4 mA 60-cycle a.c. shock, provided by a 440 V source through a fixed resistance of 1 MΩ. The CS–US interval was 5 s. The US and/or CS was terminated when the animal's hind feet crossed an electrified center barrier. Sixty trials, at two per minute, were given on every other day for a total of 600 trials (except for two animals in each group that had sixty trials on each of ten consecutive days).

Results

The mean percent avoidance responses (no US) for each day for the mongoloid and

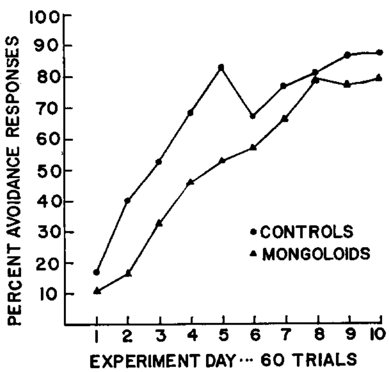

FIG. 2. Averaged learning curves for shuttle-box avoidance conditioning of fourteen hamsters with rat virus (RV) produced mongolism and fourteen normal control litter-mates (Experiment I).

normal *S*s are shown in Fig. 2. (Data were transformed to arcsines for analyses, and retransformed for graphic presentation.)

An analysis of variance on arcsine transformed scores was performed. For the mongoloid-control comparison, $F = 3{\cdot}70$, *df.* = 1,26, $P = 0{\cdot}07$. For the interaction of experimental days with treatment group, $F = 2.61$, *df.* = 9,234, $P < 0{\cdot}01$.* This seems to indicate that although the average performance of the two groups was not reliably different, the *rate* of learning was somewhat greater for normals than mongoloids.

EXPERIMENT II: SHUTTLE-BOX AVOIDANCE WITH A MODIFIED SIDMAN PROCEDURE

Results of Experiment I suggested that a more intellectually trying task might differentiate between mongoloid and normal hamsters. We chose Sidman avoidance conditioning.

Method

Subjects. Seventeen experimental hamsters were inoculated as in Experiment I, all RV inoculates developed many or all of the above-mentioned abnormalities. Seventeen control litter-mates were inoculated with normal tissue culture fluid: none showed signs of 'hamster-mongolism'.

Apparatus. In order to reduce experimenter bias, we developed an automated avoidance apparatus. The shuttle-box was of masonite except for a plexiglass front. The floor was $\frac{1}{8}$ in. stainless-steel grid bars, spaced $\frac{5}{16}$ in. apart O.D. The box was $4\frac{3}{4}$ in. high, 5 in. wide, and 14 in. long. It was supported by a shaft which turned in a ball-bearing mount, allowing the box to tip slightly with changes of the *S*'s position, making and breaking mercury dip-pot contacts. There was very little friction, and the cages moved easily under animals of any weight. However, a possibility remained that the greater mass of normals as compared to 'mongoloids' might result in faster contact closure. To compensate, the mass of the box was adjusted. The initial mass of the entire box was 890 g without a top. For the mongoloids a top weighing 216 g was used; for the controls a top weighing 1026 g was used. This brought

* In Experiments I through IV probability levels for several analysis of variance factors involving the interaction of the Days variable with other variables, such as mongoloid versus controls, are given and interpreted. These probability levels and their interpretations should be viewed with caution. The error variance estimate for *F* ratios involving these 'repeated measures' factors was taken from the sum of squared deviations for the interaction of *S*s with Days within treatments. While this is a commonly used procedure for evaluating effects of this kind, it involves assumptions of homogeneity of underlying variance and covariance matrices. If these assumptions are not valid, the resulting *P* value is based, in effect, on an inflated number of degrees of freedom. The *P* values given in the body of the paper for the interaction of Days with the mongoloid-normal comparison are: for Experiment I, 0·01; for Experiment II, 0·01; for Experiment III, 0·15 (and 0·05 for a reanalysis involving only severely afflicted *S*s). (No value for *P* is given for this effect for Experiment IV, since *F* is less than 1.) These values were re-estimated by the more conservative GREENHOUSE and GEISSER approximation,[4] which is based on a number of degrees of freedom which is certainly no greater than the 'true' number, and quite likely much less. Resulting two-tailed probability levels were, in the order just given: 0·12, 0·06, 0·22 and 0·18, none of which, by itself, would be a sufficient basis for a conclusion that normals and mongoloids differ reliably. However, if the conservative *P* values given by Greenhouse and Geisser approximation for the Days X normal-mongoloid interaction in Experiments I, II, III (full group) and IV are combined by *z* transformation, an overall *P* of 0·06 is obtained. This marginally significant difference agrees substantially with the conclusion reached in the body of the paper on the basis of the irregular results observed over the series of avoidance experiments. Thus, by either approach, the same guarded conclusion is suggested; namely, that mongoloid hamsters usually learn avoidance tasks somewhat more slowly than normals.

the ratio of total box mass for mongoloids versus controls to 0·58. The comparable ratio of mean body weights was 61·7/111·4 = 0·55. Thus, the angular momentum of the system was approximately proportional to the weight of the *S*s, and therefore, the actuation characteristics of the apparatus were also theoretically equal. Several calibration checks substantiated the near equality. The weight required to actuate the switches at 5 in. from the fulcrum was 21·0 g with the heavy top, 13·5 g with the light top, a ratio of 0·64. Comparisons between well-trained control and experimental hamsters under escape-only conditions disclosed no appreciable differences in recorded latencies. In sum, within some small margin of error, the apparatus behaved the same way for the two groups. In addition, within-group correlations for control animals between weight and overall performance were negligible. Thus, any remaining differences could not have affected the results.

There were two boxes, the use of which was counter-balanced across groups, housed in sound-isolated compartments in a separate room from automatic electric recording and control apparatus. There was a 24 V d.c. miniature bulb as house light in each enclosure. The US was an 0·8 mA scrambled grid shock.

Procedure. Each *S* was run for one 30-min session on each of 5 successive days. A shock was delivered each 15 s unless *S* crossed the box and tripped the switch within the 15-s interval. If he did so, the onset of the shock was postponed by 15 s. If the shock came on, it remained until *S* responded. Thus, the schedule may be described as a modified Sidman avoidance with a 15-s response–shock interval and response-terminated shock.

Results

Figure 3 shows average learning curves for the two groups as measured by total amount of shock received (times were converted to logs for analysis and means retransformed for

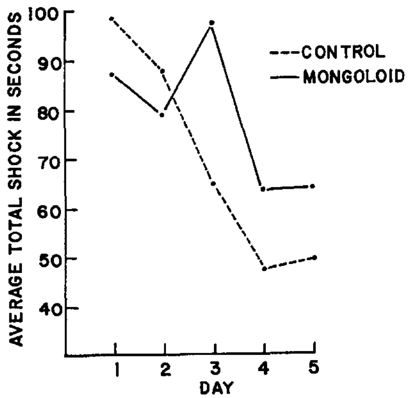

FIG. 3. Learning curves for control and experimental hamsters on Sidman-type shuttle-box avoidance (Experiment II).

graphic display). As in Experiment I, the overall difference between mongoloid and control animals was not significant ($F = 1{\cdot}970$, $df. = 1{,}33$, $P < 0{\cdot}25$), but the treatment by day interaction was reliable ($F = 3{\cdot}891$, $df. = 4{,}128$, $P < 0{\cdot}01$).* The controls appear to have improved somewhat more during the 5 days of training.

* See footnote to p. 97.

EXPERIMENT III: AUTOMATED SHUTTLE-BOX AVOIDANCE WITH VARIATION IN TRIAL DISTRIBUTION

This experiment was performed in order to replicate Experiment I and utilized an apparatus which would reduce the experimenter's role; i.e. the automated shuttle-box used in Experiment II. In addition, it was thought that the observed deficit in learning rate for mongoloid hamsters might lie in a factor, such as rate of neural consolidation, which is magnified by trial massing. McGAUGH, JENNINGS and THOMSON[5] have presented evidence which suggests this to be the case for the genetically-based inferiority of Tryon dull rats, for example. A difference of this kind is especially indicated if, as suggested by the results of Experiments I and II, differences are in rate of acquisition rather than terminal performance.

Method

Subjects. Thirty-six virus-induced mongoloid hamsters and thirty-six normal control litter-mates, prepared in the same manner as Experiment I, were tested. All were between 44 and 59-days-old at the start of testing.

Apparatus. The same automated shuttle-boxes were used as in Experiment II. The US was the same as in Experiment II; i.e. 0·8 mA shock. The CS consisted of onset of the house light plus a moderate level 1300 c/s tone delivered through a small loudspeaker in the enclosure.

Procedure. Each animal was run for fifty trials on each of thirteen consecutive days, in a standard shuttle-box avoidance procedure with response terminated CS and US. There were four groups: mongoloid massed (MM); mongoloid spaced (MS); control massed (CM); and control spaced (CS). In the massed condition, trials began every 20 s; in the spaced, every 60 s. For both massed and spaced conditions there was a 5-s CS–US interval. For both conditions, the shock and CS terminated when the animal moved to the side opposite the one in which he was at the beginning of the trial, or after 10 s if no response had occurred. The experiment was run in three replications of twenty-four animals, six per group. One control and one mongoloid were always run simultaneously, and the two boxes and times of running were counter-balanced across groups.

Retention test. Two months after the last session for the third replication group, all surviving animals were given 2 days of testing under the same conditions in which they had been run originally. The first day of retention testing was, thus, 66, 80, or 98 days after the last day of initial training for *S*s in the three replications.

Results

Learning curves for the four groups are shown in Fig. 4. (Data were transformed to 2 arcsine $\sqrt{(x)}$ for analysis and means retransformed for graphic presentation.) Analysis of variance confirms the apparent lack of differences between groups in this experiment (for mongoloids vs. controls, $F < 1$; for massed vs. spaced, $F = 1{\cdot}973$, $df. = 1{,}68$, $P < 0{\cdot}15$;* for the interaction of mongoloid-control with the spacing variable, $F < 1$; for the interaction of mongoloid-control with day of testing, $F = 1{\cdot}519$, $df. = 12{,}816$, $P < 0{\cdot}25$; for the remaining two interactions, $F < 1$; and only the Days factor is significant with an F of 112).

* See footnote to p. 97.

Failure to replicate the previously found difference in rate of learning between mongoloid and control animals presents a puzzle. One possibility is that the virus used had lost some of its virulence, so that the abnormalities produced were less severe than in the previous experiments. Indeed, it was our subjective impression that the virus-inoculates in this

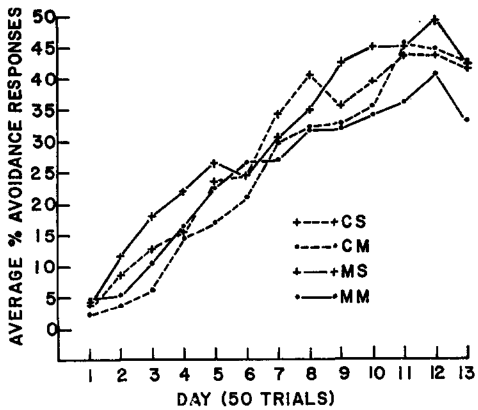

FIG. 4. Learning curves for control spaced (CS), control massed (CM), mongoloid spaced (MS), and mongoloid massed (MM) groups on shuttle-box avoidance in Experiment III.

experiment were less mongoloid in appearance than previous batches. In order to test this notion, the relation between observed symptomology in the animals and their performance in the experiment was studied.

One of the experimenters who had not been involved in actual running of the learning tests for this experiment blind rated all of the hamsters for degree of manifestation of mongoloid features. A five-point scale (1 = normal) was used on which reasonably good reliability was obtained (84 per cent of judgements agreed within one point with those of an independent rater). Ratings were made only for the twenty-four animals of the last replication. Significantly more RV inoculates received 4 and 5 ratings than did control animals ($P < 0{\cdot}05$ by Fisher exact test), from which it can be concluded that the virus had at least some effect.

When only mongoloids with ratings of 4 or 5 are included in the analysis, a similar pattern of differences appears to that in the previous experiments. Learning curves for the seven virus-inoculates so rated and the twelve controls from the last replication are shown in Fig. 5. Massed and spaced groups have been combined. Once again the overall performances did not differ significantly ($F < 1$) but there is a significant interaction of the mongoloid-control factor with experimental day ($F = 1{\cdot}95$, $df. = 12{,}204$, $P < 0{\cdot}05$).* Controls appeared to improve somewhat more than mongoloids.

Retention test. On the retention test thirty-two mongoloid and twenty-nine control *S*s remained. For analysis the three replications were combined. The number of *S*s from the four original treatment groups were respectively: MM, 15; MS, 14; CM, 17; and CS, 15.

* See footnote to p. 97.

The mean (inverse transform of mean of data transformed to 2 arcsine $\sqrt{(x)}$) per cent avoidances on the two days for these groups were, respectively, 22·7, 49·9, 26·2 and 55·8. Analysis of variance was performed by unweighted means on transformed data. For the mongoloid–control comparison, $F = 1{\cdot}30$, $df. = 1{,}57$, n.s.; for the spacing variable, $F = 31{\cdot}49$, $df. = 1{,}57$, $P < 0{\cdot}001$; for the interaction $F < 1$. The expected spacing effect

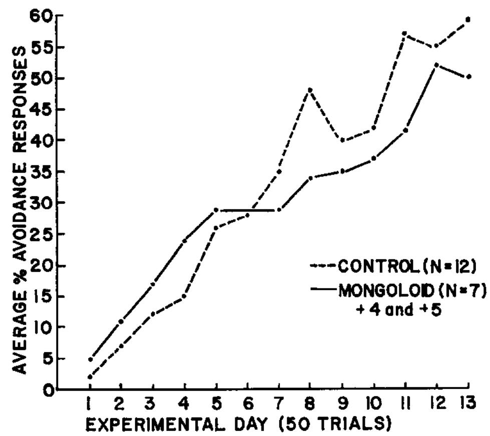

FIG. 5. Learning curves for control and severely affected RV inoculated hamsters from third replication of Experiment III.

appeared in retention data where it had not during initial training. However, spacing did not interact significantly with mongoloid–control differences in retention. Controls were again insignificantly superior to mongoloids in overall performance.

EXPERIMENT IV: SHUTTLE-BOX AVOIDANCE: REPLICATION

The lack of consistent results in these avoidance experiments and particularly the suspicion that the experimental animals had been insufficiently affected by the virus in Experiment III, led us to attempt still another replication of the basic avoidance conditioning experiment, this time with clearly mongoloid experimental animals.

Method

Subjects. Twenty virus-induced mongoloid hamsters and twelve normal control litter-mates prepared in the same manner as in Experiments I, II and III were tested. The virus-inoculates all showed pronounced symptoms; e.g. there was no overlap in the distribution of body weight for normal and experimental animals.

One control animal died before the end of the training series.

Apparatus. The same automated shuttle-boxes and conditions were used as in Experiments II and III.

Procedure. The same four treatment groups were run as in Experiment III. Because of the uneven numbers of animals in the experimental and control groups, pairing of running times was incomplete. Otherwise, all procedures were the same as in Experiment III.

Results

Learning curves for the four groups are shown in Fig. 6. (Data were transformed to 2 arcsine $\sqrt{(x)}$ for analysis and means were retransformed for graphic presentation.) An analysis of variance by unweighted means on transformed data was performed. The overall mongoloid-control difference was significant ($F = 5{\cdot}36$, *df.* = 1,28, $P < 0{\cdot}05$), this time favoring the mongoloids. The spaced-massed difference was also significant ($F = 13{\cdot}19$,

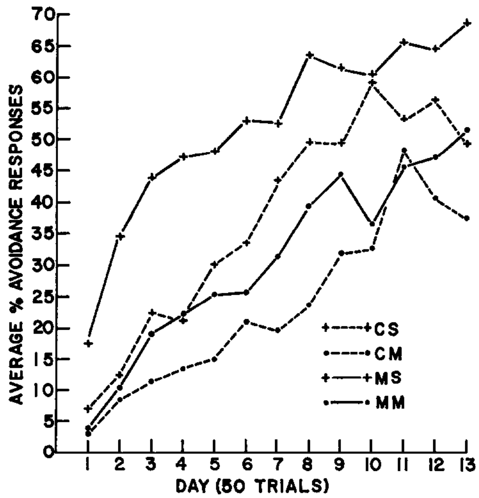

FIG. 6. Learning curves for control spaced (CS), control massed (CM), mongoloid spaced (MS), and mongoloid massed (MM) groups on shuttle-box avoidance in Experiment IV.

df. = 1,28, $P < 0{\cdot}01$). None of the interactions were significant. (For all two-way interactions, $F < 1$. For the three-way interaction of experimental day X spacing X type of animal, $F = 1{\cdot}70$, *df.* = 12,324, $P < 0{\cdot}10$.)

Because of the small number of control *S*s in this experiment, the statistical analysis was repeated comparing the twenty mongoloids of this experiment with twenty randomly chosen control *S*s from Experiment III. The results were quantitatively the same, and the significance level of the mongoloid–control comparison was considerably lower ($P < 0{\cdot}001$).

Thus, in this experiment, not only did the greater learning rate for normals observed in three previous experiments not appear, but also there was an overall performance superiority for the mongoloids.

EXPERIMENT V: OPEN FIELD TESTS

One possible explanation for the superior performance of the mongoloids despite the slower rate of learning previously found, is that they are more generally active and/or less emotional, and that this characteristic leads to better performance in an aversive training situation. Unsystematic observation led us to believe this might be the case. To quantify activity levels, an open field test was used.

Method

Subjects. The same twenty mongoloid and eleven control *S*s previously used in Experiment IV were run in the open field test.

Apparatus and procedure. The field consisted of a circular enclosure with a radius of 24 in., bounded by a sheet metal wall. Its floor was divided by painted markings into four 6 in. concentric rings and these rings further subdivided into 3, 6, 12 and 16 parts respectively for the innermost ring to the ring nearest the wall. Each animal was placed in the field, near the wall, and observed for 5 min. Time locomoting, number of segments entered, and number of inner (not next to the wall) segments entered were taken as data.

Results

The principal activity measure from open field observations is the amount of time spent moving. Mongoloids averaged 124·3 s and controls 90·0 s. This difference is significant, $P < 0{\cdot}02$ by a two-tailed Mann–Whitney test. Mongoloids entered an average of 83·0 segments of which 26·1 were inner segments, controls 58·5 and 14·7 respectively. The difference for total segments was significant ($P < 0{\cdot}05$ by two-tailed Mann–Whitney test); the difference for inner segments was not ($P < 0{\cdot}20$) by two-tailed Mann–Whitney test.

EXPERIMENT VI: HEBB–WILLIAMS MAZE

Difference in activity in the open field test is commonly interpreted as a measure of emotionality (e.g. DENENBERG[6]). Since avoidance conditioning may reflect some combination of emotional and intellectual factors, a test of intellectual abilities with a smaller emotionality component, such as the Hebb–Williams maze, was indicated as a means of expanding the description of the behavioral characteristics of the experimental animals.

Method

Subjects. Fifteen mongoloid and nine normal control animals surviving from Experiments IV and V began pretraining for the Hebb-Williams maze. One mongoloid did not meet criterion on the practice problems and was discarded.

Apparatus and procedure. A description of the maze can be found in RABINOVITCH and ROSVOLD.[7] Dimensions were unchanged, except that start and goal boxes were smaller and were detachable and interchangeable. For three days prior to training, *S*s were fed on an open table in groups of three or four, and were handled by *E* as a taming procedure. All *S*s were on an 11-h deprivation schedule and maintained at 80 per cent free-feeding weight. Practice problems were given as described by Rabinovitch and Rosvold and continued to a criterion of six runs in 45 s. As soon as an animal met criterion, it was started on the series of test problems as described by Rabinovitch and Rosvold. Only the first eight of these problems were used. Errors (wrong turns) and total time required for traversing the maze six times were taken as data on each problem for each *S*. *S*s were run on one problem per session, with two sessions each day at about 12-h intervals, with a new problem at each session. The floor of the maze was washed after each *S*'s series.

The experiment was run in two replications, each involving half the animals. Procedures for the second replication differed in a few details from the first. In the first replication, *S*s were allowed several seconds access to a large food supply (wet mash) in the goal box at the end of each run, and then were removed by hand and replaced in the start box. In the second replication, a constant amount of food was placed in the goal box, equivalent to 1/12 the *S*'s daily allotment, and *S*s were allowed to eat it all. Instead of removing the animal from the goal box, goal and start boxes were interchanged. These variations in procedure were intended to reduce *E*'s contact with *S*s and, thus, the possibility of experimenter bias. There was no appreciable difference between the results of the two replications, and the data were pooled for analysis.

Results

Mongoloids made an average of 37·2 errors per test problem, compared to 26·9 for controls, a difference significant at $P < 0{\cdot}02$ by a two-tailed Mann–Whitney test. Mongoloids required an average of 159·5 s per test problem, compared to 96·0 s for controls, a difference significant at $P < 0{\cdot}05$ by two-tailed Mann–Whitney test.

DISCUSSION

In three out of four avoidance conditioning experiments suggestive evidence was found of a slower learning rate for hamsters with rat-virus-induced 'mongolism' than for normal litter-mate controls. It seems reasonable to conclude that the syndrome produced by the virus usually includes some trait(s) which are inhibitory with respect to acquisition of this kind of response. On the other hand, in three of four experiments, the overall difference in performance, over 10–13 daily sessions (600–650 trials), while greater in normals, did not significantly differentiate them from the virus-treated animals, and in the fourth experiment was significantly greater for the treated animals than for the controls. This suggests that the virus-produced syndrome also includes some characteristic(s) which promotes superior performance in this task.

The finding of greater activity on the part of the 'mongoloids' in the open field test at first glance appears to offer an attractive possibility as the postulated positive factor in avoidance performance. It is possible that high performance levels in avoidance conditioning and activity in the open field are associated. One could postulate, for example, that the low emotionality indicated by activity in the open field reduces the amount of incompatible 'freezing' behavior in the shuttle-box, or, on the other hand, that the high activity is a general trait and simply leads to more box-crossings in the avoidance conditioning task. The 'mongoloid' hamsters can be interpreted to be less emotional on the basis of the open field test and less intelligent on the basis of the Hebb–Williams maze results. Their avoidance conditioning performance might, thus, result from a combination of a low-learning rate due to low intelligence and a high performance level due to high activity and/or low emotionality.

This explanation, of course, depends on an hypothesized positive relation between activity in the open field and performance in the avoidance task. It is possible to test this hypothesis on data from Experiments IV, V and VI by examining correlations between the various tasks over individual control *S*s tested in all three situations. (Only correlations for control *S*s are relevant, since an association between open field and avoidance behavior in experimentals could be due to mutual association with effects of the virus.) In computing the correlation coefficients to be discussed, *S*s from the spaced and massed conditions in the avoidance conditioning task (Experiment IV) were pooled after the scores for the massed condition *S*s were adjusted by adding a constant which equalized the means of the two groups. Rank order correlation coefficients were as follows. Between number of avoidances (sum over all 13 days of 2 arcsine $\sqrt{}$ (daily total % avoidance) and amount of time active in the open field test, rho $= -0{\cdot}40$. With only eleven control *S*s this is not significantly negative, but it is certainly not the positive relation required by the hypothesis. Between the same measure of avoidance performance and total number of errors in the Hebb–Williams maze, rho $= -0{\cdot}60$, $n = 9$, $P < 0{\cdot}05$. Thus, for control animals, superior Hebb–Williams performance *is* associated with superior avoidance performance. Apparently, then, under normal conditions (i.e. control animals), overall performance in shuttle-box avoidance is not positively associated with low emotionality as measured in the open field, while it is positively related to intelligence as measured by the Hebb–Williams maze.

Thus, the greater open field activity of 'mongoloids' as compared to normals does not account for the 'mongoloid's' superiority (or at least equality despite lower learning rate and lower Hebb–Williams learning) in performance on the avoidance task. This does not mean that the 'mongoloids' are not less emotional than controls—by the usual interpretations they are—but that this lower emotionality is probably not the facilitative factor in their avoidance behavior.

Further evidence of the existence of such an avoidance facilitating factor associated with virus 'mongolism' is found in the correlation between tasks for the treated animals. If the disorder leads both to low intelligence as measured by the Hebb–Williams maze and to greater performance in avoidance, then the more severely affected hamsters should tend to make more errors on the Hebb–Williams maze and make more total avoidance responses, thus tending to reverse the normal negative relation between the two task scores as seen in the controls. In fact, for Hebb–Williams errors versus overall avoidance scores among 'mongoloids', rho $= 0{\cdot}11$, which is significantly more positive ($P < 0{\cdot}01$) than the comparable correlation ($-0{\cdot}60$) for controls.

Thus, we are unable to account for the fact that the overall avoidance performance of 'mongoloid' hamsters is comparable to or better than that of normal controls. The affected animals have two characteristics, each to a significant extent as compared to normals, which are correlated among normals with poor performance in shuttle-box avoidance, and yet they are not poor performers in this task! Apparently shuttle-box avoidance, at least as used here, involves some as yet unidentified factor which is a characteristic which 'mongoloid' hamsters may have in excess of normal animals. It should be noted that this conclusion is not based simply on a failure to find a significant difference in the first three experiments. Had this been all the data, we might have concluded that the differences were simply washed out by a large series of training trials in which a common asymptote was approached over the last portion. Experiment IV, however, produced evidence of a clear superiority of the 'mongoloids' over normals in overall performance.

CONCLUSIONS

The behavioral characteristics of hamsters with the rat-virus-induced 'mongolism' syndrome, as compared with normal controls, may now be summarized as follows: 'Mongoloids' tend to learn shuttle-box avoidance somewhat less rapidly than do controls, but they may exceed controls in overall performance in some instances. 'Mongoloids' are more active than their control litter-mates in an open field test. 'Mongoloids', as compared to controls, are poor spatial problem solvers in the Hebb–Williams maze. It would probably not be too inaccurate to say that virus 'mongoloid' hamsters are low in intelligence and at the same time rather low in anxiety and high in activity. The similarities of these traits to those frequently described for humans with Down's syndrome[8] may, of course, be coincidental. However, they may also represent the results of underlying etiological similarities sufficiently close to justify further investigation. While the involvement of a chromosomal aberration has been established in the case of human 'mongolism',[9] the proximal physical defects giving rise to the psychological characteristics of the disorder have not been elucidated. Virus-induced hamster 'mongolism' may provide a useful laboratory model in this regard.

SUMMARY

Hamsters with the rat-virus-induced 'mongolism' syndrome were compared with normal control litter-mates on several tasks. In shuttle-box avoidance, both standard and of a Sidman type, affected *S*s showed a slower learning rate in three of four experiments, but a higher overall performance in one of four. They were more active in an open field test and made more errors in the Hebb–Williams maze. The syndrome produced by early sub-lethal doses of rat-virus thus appears to include lowered learning ability, coupled with higher activity or lower emotionality.

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