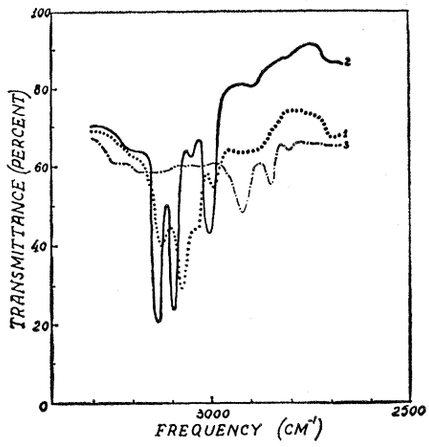

Fig. 4. Infrared spectra at 20 kb; curve 1 (dotted), liquid acrylonitrile; curve 2 (solid), solid acrylonitrile (phase II); curve 3 (dot-dash), polyacrylonitrile.

line form II.) The spectra were taken by the following procedure. Initially, pressure was increased up to 20 kb, and the sample was allowed to stand overnight. No crystallization occurred. The spectrum of this liquid acrylonitrile is shown in Fig. 4 (curve 1). The pressure was then increased up to 36 kb, at which pressure the crystalline modification II formed. The spectrum of this form was recorded after releasing the pressure to 20 kb (Fig. 4, curve 2). The pressure was then decreased until the polymerization took place; after that, it was increased to 20 kb, and the spectrum of the polymer was recorded (Fig. 4, curve 3).

The band positions of the liquid acrylonitrile under pressure, which are shown in Fig. 4, are in satisfactory agreement with those reported for liquid acrylonitrile at atmospheric pressure (*6*). In the region of frequencies presented, bands were found at 2990, 3033, 3068, and 3125 cm^{-1}. We have found the bands at 2992, 3035, 3075, and 3125 cm^{-1}. The corresponding bands of crystalline acrylonitrile are more intense and shifted slightly to higher frequencies (about 15 cm^{-1}). The spectrum of the same sample in which polymerization has taken place shows no absorption at frequencies higher than 3000 cm^{-1}. There are two bands at 2850 and 2925 cm^{-1}. Liang and Krimm have observed bands at 2870 and 2940 cm^{-1} for polyacrylonitrile (*7*). These bands were assigned to the symmetric and asymmetric stretching C—H vibrations in the CH_2 group. It seems reasonable to give the same assignment to the bands found here, in spite of some difference in the frequencies.

Polymerization of acrylonitrile proceeds below the pressure at which melting occurs. The reaction usually starts at one or two points and is developed from these points by "jumps" to cover all the viewed area. The beginning of the process was observed when the pressure was increased. If the polymer phase is allowed to cover only a part of the field, an increase of pressure stops further growth of the phase. The data on radical heterogeneous polymerization of acrylonitrile show that increasing the pressure up to 6 kb gives rise to an explosion which should be considered a result of the great rise in the polymerization rate (*1*). On this account the polymerization of the acrylonitrile in the diamond cell may not be a radical polymerization. However, the lack of an uncontrollable reaction in this case may be due in part to better temperature control because of the relatively large surface-to-volume ratio of the sample. The monomer crystallization does not seem necessary for the polymerization to occur. We have observed some polymerization without preliminary crystallization by decreasing the pressure from 20 kb.

The polymerization process discovered in this work shows rather interesting features and deserves to be investigated in more detail.

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Inheritance of Reactivity to Experimental Manipulation in Mice

Abstract. *The mode of inheritance of open-field defecation was found to differ according to earlier treatment of the mice. Activity of hybrids, however, was closer to that of the less active parent for all conditions of pretreatment. These results suggest that adequate sampling not only of gene pools, but also of both pretest and test environments, is necessary before statements concerning effects of prior treatment, or mode of inheritance of specific behavior, are valid.*

The value of genetic studies in determining the evolutionary significance of certain behaviors has been proposed (*1*). An implicit assumption in such quantitative studies is that either no environment-gene interaction exists or that environmental conditions have been adequately sampled (*2*). Most investigators using designs adequate for analyzing genetic effects have, however, limited their studies to naive animals reared under one fairly restricted environmental condition. Since there is evidence that pure strains differ greatly in reactivity to experimental manipulation (*3*) and that buffering effects may occur in interstrain hybrids (*2*), the neglect of gene-environment interactions is extremely precarious with regard to behavioral traits. Unfortunately, most investigators interested in combined genetic and environmental effects have limited their studies to pure strains only, so that genetic effects cannot be analyzed in detail as by Broadhurst (*4*) and Bruell (*5*).

I have investigated genetic influences on reactivity to various amounts of environmental stimulation, with a diallel mating system; this report describes only the mode of inheritance of defecation and exploratory activity in an open field under three different conditions of prior treatment (*6*).

A total of 1440 C57Bl/10 J, DBA/1 J, C3H J, and Balb/C J mice and their

crosses were equally divided into three 4 × 4 diallel designs, with 15 males and 15 females in each of the treatment-mating combinations. Except for weaning, the 480 mice in the first diallel design were undisturbed before they were adult and before open-field testing. The 480 mice in the second group were allowed to explore a small maze (*7*) during two 40-minute sessions on days 56 and 57; during each session a buzzer sounded intermittently for 8 minutes in all. The third group also was given two 40-minute sessions in the exploratory maze, but with classical conditioning (*7*), receiving a total of 16 0.5-second 1-ma shocks in addition to the buzzer treatment. For convenience, the three treated groups are respectively designated undisturbed, moderately stimulated, and shocked.

At the age of 10 weeks the mice were tested for 5 minutes in a 90 cm-square open field; suspended 45 cm above it was a red reflector floodlamp that applied 9.3 lumen/cm^2 in the center and 3.7 lumen/cm^2 near the walls. The white plastic floor of the field was divided into four equal 45-cm quadrants by two photoelectric beams intersecting at right angles. A mouse crossing either beam registered a count; from its total count was estimated a mouse's exploratory activity.

Defecation scores were transformed to the form $\sqrt{X + 0.5} - 0.71$ for analysis. Standard analysis of variance indicated highly significant ($p < .001$) gamete effects for both sires and dams in each of the treatment conditions. And a combined analysis indicated highly significant ($p < .001$) effects of treatment and treatment × gamete interactions.

Summed across all genetic combinations, defecation scores increased with increasing amounts of prior stimulation; mean, transformed, defecation scores were .68, .74, and .87 for undisturbed, moderately stimulated, and shocked groups, respectively. The significant treatment × gamete interaction was caused primarily by greater treatment effects on crosses with C57 and DBA parents than on crosses with C3H and Balb/C parents.

The primary concern of this paper is comparison (Fig. 1) of inbred strains with their crosses to determine the mode of inheritance of open-field behaviors following each of the treatment conditions. When one combined males and females, pure strains and

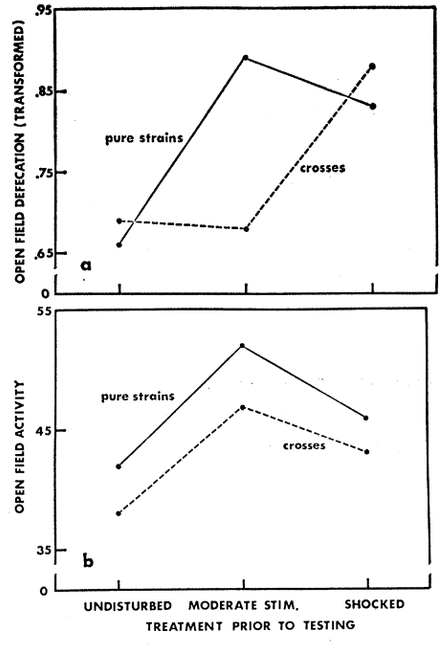

Fig. 1. Open-field scores in defecation (transformed) (*a*) and ambulatory activity (*b*).

their crosses were not significantly different among the undisturbed subjects; an intermediate mode of inheritance was indicated for defecation in a strange environment (*8*)—like Broadhurst's (*4*) results from a study of emotional defecation with rats. Pure strains and crosses were also insignificantly different among shocked groups; again an intermediate mode of inheritance was suggested. Among subjects receiving moderate prior stimulation, however, mode of inheritance was dominant toward the lower-scoring parent; crosses defecated significantly less than their mid-parents ($p < .001$) and were not significantly different from their lower-scoring parent.

Depending upon the environmental background of the investigator's colony, his conclusions concerning mode of inheritance of emotional defecation could vary considerably. Although one could speak of different modes of inheritance under different environmental conditions, it appears more reasonable in this instance to suggest that pure strains have a lower threshold of reactivity to outside intervention by the experimenter than do crosses. Unlike the pure strains, crosses appeared adequately "buffered" against the relatively mild stimualtion in the second treatment, but did react to the more severe shock treatment.

As with defecation, differences between pure strains and crosses in open-field ambulation scores (Fig. 1*b*) show highly significant ($p < .001$) sire and dam effects for all treatment conditions, in addition to significant ($p < .001$) treatment, and gamete × treatment, interaction effects. In this instance, however, conclusions concerning overall mode of inheritance are the same for all conditions of treatment. Across all treatments, crosses showed slightly but significantly less activity ($p < .001$) than pure-strain parents, but were still closer in score to these midparents than to the lower-scoring parents ($\bar{X}$, 32); slight dominance of genes from the less-active parent was indicated.

The mode of inheritance of open-field activity, therefore, appears to be consistent over a wide range of levels of prior stimulation. One should note, however, that, although activity in this instance was below the midparent score, activity in a closed maze has been shown to be greater in F_1 mice than in either parent (*1*). Just as one cannot make a general statement about mode of inheritance of emotional defecation, one cannot speak of a mode of inheritance of exploratory behavior without reference to environmental test conditions. If heterotic or dominant inheritance occurs only in traits that have been subjected to selection (*1, 2*), it would appear that exploration in a darkened labyrinth is advantageous to the species while exploration in a well-lighted open area is not.

The results of my experiment, along with earlier data, question the adequacy of studying mode of inheritance of a given behavioral trait without systematic variation of both pretest and test environments. Furthermore, it has been shown that at different ages C57Bl/10 J mice are more or less susceptible to effects of experimental manipulation (*9*) and that strain × age interactions can occur in certain behaviors (*10*).

A basic dilemma therefore occurs for investigators interested in genetic, treatment, or age effects because all three factors apparently interact. It would appear then that, unless an investigator examined specific behaviors in natural environmental and natural test situations, large, elaborate experimental designs—varying all the above parameters—would be necessary for adequate study of any one of these variables.

The first approach would have the advantage of proportionately sampling

the typical range of stimulation levels and environments of the species; perhaps it would be most relevant for studying evolution of behavior. The second approach, however, enables systematic analysis of the influence of various environments and test situations on behavior of the species.

The existence of interactions between variables does not imply that general statements cannot be made about genetic, age, or environmental factors per se. Significant main effects may still be the primary concern of the investigator and may frequently emerge. The value of such results increases considerably, however, if it is known that the effect occurs over a wide range of conditions and if the investigator is aware of specific interactions.

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High-Speed Scanning in Human Memory

Abstract. *When subjects judge whether a test symbol is contained in a short memorized sequence of symbols, their mean reaction-time increases linearly with the length of the sequence. The linearity and slope of the function imply the existence of an internal serial-comparison process whose average rate is between 25 and 30 symbols per second.*

How is symbolic information retrieved from recent memory? The study of short-term memory (*1*) has revealed some of the determinants of failures to remember, but has provided little insight into error-free performance and the retrieval processes that underlie it. One reason for the neglect of retrieval mechanisms may be the implicit assumption that a short time after several items have been memorized, they can be immediately and simultaneously available for expression in recall or in other responses, rather than having to be retrieved first. In another vocabulary (*2*), this is to assume the equivalence of the "span of immediate memory" (the number of items that can be recalled without error) and the "momentary capacity of consciousness" (the number of items immediately available). The experiments reported here (*3*) show that the assumption is unwarranted.

Underlying the paradigm of these experiments is the supposition that if the selection of a response requires the use of information that is in memory, the latency of the response will reveal something about the process by which the information is retrieved. Of particular interest in the study of retrieval is the effect of the number of elements in memory on the response latency. The subject first memorizes a short series of symbols. He is then shown a test stimulus, and is required to decide whether or not it is one of the symbols in memory. If the subject decides affirmatively he pulls one lever, making a positive response; otherwise he makes a negative response by pulling the other lever. In this paradigm it is the identity of the symbols in the series, but not their order, that is relevant to the binary response. The response latency is defined as the time from the onset of the test stimulus to the occurrence of the response.

Because they are well learned and highly discriminable, the ten digits were used as stimuli. On each trial of experiment 1, the subject (*4*) saw a random series of from one to six different digits displayed singly at a fixed locus for 1.2 seconds each. The length, s, of the series varied at random from trial to trial. There followed a 2.0-second delay, a warning signal, and then the test digit. As soon as one of the levers was pulled, a feedback light informed the subject whether his response had been correct. The trial ended with his attempt to recall the series in order. For every value of s, positive and negative responses were required with equal frequency. Each digit in the series occurred as a test stimulus with probability $(2s)^{-1}$, and each of the remaining digits occurred with probability $[2(10-s)]^{-1}$.

Each subject had 24 practice trials and 144 test trials. Feedback and payoffs were designed to encourage subjects to respond as rapidly as possible while maintaining a low error-rate. The eight subjects whose data are presented pulled the wrong lever on 1.3 percent of the test trials (*5*). Recall was imperfect on 1.4 percent of the trials. The low error-rates justify the assumption that on a typical trial the series of symbols in memory was the same as the series of symbols presented.

Results are shown in Fig. 1. Linear regression accounts for 99.4 percent of the variance of the overall mean response-latencies (*6*). The slope of the fitted line is 37.9 ± 3.8 msec per symbol (*7*); its zero intercept is 397.2 ± 19.3 msec. Lines fitted separately to the mean latencies of positive and negative responses differ in slope by 9.6 ± 2.3 msec per symbol. The difference is attributable primarily to the fact that for $s = 1$, positive responses were 50.0 ± 20.1 msec faster than negative responses. Lines fitted to the data for $2 \leq s \leq 6$ differ in slope by an insignificant 3.1 ± 3.2 msec per symbol.

The latency of a response depends, in part, on the relative frequency with which it is required (*8*). For this reason the frequencies of positive and negative responses and, more generally, the response entropy (*8*), were held constant for all values of s in experiment 1. However, the test-stimulus entropy (predictability) was permitted to co-vary with s.

Both response and test-stimulus entropies were controlled in experiment 2, in which the retrieval process was studied by an alternative method similar to that used in more conventional experiments on choice-reaction time. In experiment 1, the set of symbols associated with the positive response changed from trial to trial. In contrast to this varied-set procedure, a fixed-set procedure was used in experiment 2. In each of three parts of the session, a set of digits for which the