

Temperature effect and strain differences in the nest-building behavior of inbred mice*†

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The nest-building behavior of four strains of inbred male mice was studied under three levels of temperature. The amount of cotton used in nest building was found to be a negative function of temperature. Although this relation was observed in all four strains, there were strain differences in the absolute level of nest-building behavior and in the degree of sensitivity to temperature changes.

There is some evidence that rodents are capable of adjusting to environmental temperature changes by means of operant behavior. Striker, Everett, & Porter (1968) observed that mice and rats tended to stay near water pools, splash water on themselves, or take baths at an ambient temperature of 40°C. Epstein & Milestone (1968) reported that rats learned to barpress to obtain a water shower in hot temperature. When environmental temperature was low, mice and rats built large nests with wool (Barnett & Manly, 1954), paper (Kinder, 1927), and hay (Koller, 1956). In fact, Killer (1956) demonstrated that the amount of nest-building behavior of albino mice was negatively correlated to temperature. Lee (1969) reported that under constant temperatures there were strain differences in the amount of cotton used by inbred mice. The present experiment was to investigate the effect of temperature change on the nest-building behavior of different strains of inbred mice.

SUBJECTS

Ss were 10 male mice from each of A/J, BALB/cJ, and DBA/2J and 9 male mice from C57BL/10J purchased from Jackson Laboratory. They were 6 weeks old upon arrival and 14 weeks old at the beginning of the experiment. They were singly housed in polypropylene cages and maintained ad lib with water and Purina Lab Chow throughout.

PROCEDURE

Ss were moved from the animal colony to a sound-treated chamber with controlled temperature and humidity 3 days prior to experimentation. Ss were tested at 25°, 20°, 15°, 25°, and 25°C for 5 successive weeks. The proper temperature for each

Fig. 1. The mean amount of cotton used by four inbred strains of mice under various temperature conditions.

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week was adjusted during the preceding weekend. During weekdays between 1:00 and 3:00 p.m. cotton was placed on top of the cage lids and the weight of cotton and lid was measured on a triplebeam balance. The difference between the weight of the first day and that of the following day was taken as the amount of cotton used per day. New cotton was given and the old nest was removed from the cage Monday through Friday. The nest was left in the cage during weekends.

RESULTS AND DISCUSSION

To maintain equal Ns, on any given day, the score of a randomly selected S in the C57BL/10J was treated as the score of the 10th S of that group. Figure 1 shows that the amount of nest-building material used is negative correlated with temperature. A reliable temperature effect was obtained in both the first three 4-day blocks and the last three 4-day blocks [$F(2,72) = 100.86$ and 76.39 , $p < .01$ in both cases]. This finding is in agreement with Koller's (1956) and Kinder's (1927) in rats.

Considering the first three blocks of trials, there were reliable strain differences [$F(3,36) = 35.32$, $p < .01$] and Strain by Temperature interaction [$F(6,72) = 86.62$, $p < .01$]. The rank order of the four

strains was similar to that reported by Lee (1969). BALB/cJ not only used the most amount of cotton but also seemed to be most sensitive to temperature decrease. DBA/2J showed little increment in cotton consumption as temperature was reduced; however, an analysis of simple effect of temperature for DBA/2J revealed a significant temperature effect [$F(2,18) = 10.28$, $p < .01$].

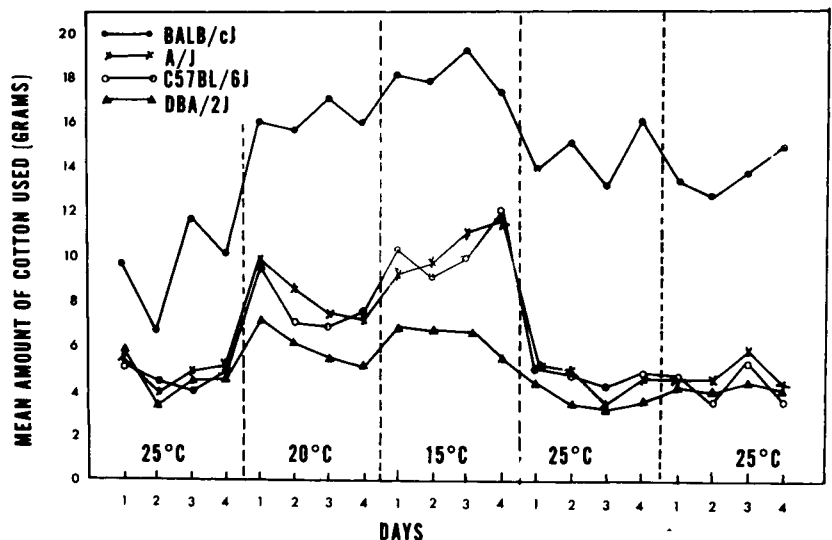
When temperature was raised to 25°C, the amount of cotton used by all strains except BALB/cJ fell back to the original level. Analysis on the data of the first and the last two blocks for each strain revealed a reliable block effect only for BALB/cJ [$F(2,18) = 10.28$, $p < .01$]. Although BALB/cJ's cotton consumption did not return to the original level, it was significantly less than when the temperature was at 15°C [$F(2,18) = 6.19$, $p < .05$]. It is interesting to note that while this strain was most sensitive to temperature increase it was least sensitive to temperature decrease.

The mean intraclass correlation coefficients (Fuller & Thompson, 1960; Parson, 1967) for the five 4-day blocks were 0.50, 0.62, 0.58, 0.71, and 0.64, respectively. These coefficients may be taken as reflecting a broad heritability in nest-building behavior.

In terms of qualitative differences of the nests built, BALB/cJ and A/J tended to build ball nests with a shallow spot inside, while C57BL/10J and DBA/2J preferred bowl-shaped nests. A similar observation was also reported by Lee (1969).

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was recorded, and this value was used as an *index of activity*. Performance of the recipients was expressed in terms of the number of errors made before the 90% criterion at two consecutive sessions was attained.

Table 1 shows that Group CR made fewer errors than Group CN. An analysis of variance showed that the difference was significant to the level of $p < 0.01$. *There was no significant difference in exploratory activity between the two groups.*

The results of these and of our previous experiments (Chapouthier, Pallaud, & Ungerer, 1969) suggest that the brain of trained animals contains some material, absent from the brain of untrained animals, which accelerates the rate of learning in the recipients. They confirm the results previously obtained with conditioned avoidance by Ungar (1966) who, however, used rats as donors. Our results indicate that the increased learning ability of the experimental group is not due to higher spontaneous activity, but they do not allow us to decide whether it is specific for the task learned by the donors or reflects an overall facilitation of learning by some material present in the brain of trained animals.

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Facilitation of learning by injection of brain extracts*

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The rate at which mice acquire a single conditioned avoidance response is increased by the injection of suitably concentrated brain extract from conditioned animals. This effect cannot be attributed to an increase in general activity of the treated animals.

The possibility of inducing behavioral changes by administration of brain extracts was first reported in 1965 (Reinis; Fjerdingstad, Nissen, & Røigaard-Petersen; Ungar & Ocegüera-Navarro; Babich, Jacobson, Bubash, & Jacobson) and the reports have been confirmed in the last few years in at least 15 other laboratories (Ungar, in press). The negative results obtained by some workers (Byrne et al, 1968) can be explained by inadequate training of donors, insufficient doses of extract administered, or confusion over the nature of the active material, which resulted in the use of inactive preparations (Ungar, in press).

METHOD

The experiments reported in this paper were carried out in Swiss mice (male, 2 to 3 months old). The donors were trained to acquire a simple conditioned-avoidance response in a shuttlebox (24 x 12 x 12 cm) whose two compartments were divided by an opaque partition provided with an opening. Before the first trial, each animal was allowed to explore the apparatus freely for 10 min. The trial consisted in the presentation of the conditioned stimulus (sound coupled with light) for 5 sec followed by an electric shock of 30 to 40 V through the grid that formed the

floor of the box. Correct response was recorded when the mouse ran into the other compartment on the conditioned stimulus and thereby avoided shock. Each animal was given 20 trials daily until the criterion of 90% correct responses on five consecutive sessions was reached.

The donors were killed 24 h after the last training session. Their brains were rapidly removed and kept at -40°C . Control brains were taken from untrained donors and treated identically with those collected from trained animals. Each group consisted of 48 animals.

Pooled brains from each group were homogenized in saline. The homogenates were kept overnight at 2°C and centrifuged for $2\frac{1}{2}$ h at $24,000 \times g$. The supernatant was injected intraperitoneally into recipients: one group of 12 mice received the equivalent of four brains from trained donors (CR) and a second group of 12 the same amount from naive donors (NR).

Twenty-four hours after the injection, the recipients were trained identically with the donors. During the 10-min exploratory period, the number of times the animals moved from one compartment to the other

Table 1
 Rate of Conditioning and Exploratory Activity in Mice Injected with Brain Extracts from Trained (CR) and Naive Donors (NR)

Group	Mean		Mean		N
	Number of Errors to Criterion	\pm SD	Index of Activity	\pm SD	
CR	71.1	25.8	33.6	5.7	12
NR	122.4	47.0	34.7	7.4	12
P	<0.01		>0.05		

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