References and Notes

1. J. W. Papez, *Arch. Neurol. Psychiat.* **38**, 725 (1937); P. D. MacLean, *Psychosom. Med.* **11**, 338 (1949); M. B. Arnold, *Emotion and Personality* (Columbia University Press, New York, 1960).
2. E. A. Spiegel, H. R. Miller, M. J. Oppenheimer, *J. Neurophysiol.* **3**, 538 (1940); P. Bard, in *Feelings and Emotions*, M. L. Reymert, Ed. (McGraw-Hill, New York, 1950); L. Schreiner and A. Kling, *J. Neurophysiol.* **16**, 643 (1953).
3. S. P. Grossman, *Am. J. Physiol.* **202**, 872 (1962).
4. This was preceded by application of a fraction of 1 μg of physostigmine, which did not, by itself, elicit comparable effects.
5. Choline chloride carbamate (carbachol) is a parasympathomimetic which is not hydrolized by cholinesterase and therefore produces a much more prolonged cholinergic stimulation.
6. S. P. Grossman, *Science* **132**, 301 (1960); *Am. J. Physiol.* **202**, 872, 1230 (1962); *J. Comp. Physiol. Psychol.*, in press; R. Hernandez-Peon, G. Chavez-Ibarra, P. J. Morgane, C. Timo-Iaria, *Nature*, in press.
7. Supported by grant No. MY 5331 from the National Institutes of Health. The chemicals used in these experiments were kindly provided by Merck, Sharp and Dohme, Rahway, N.J. Some of the initial observations were made in collaboration with F. P. Gault, Yale University.

23 July 1963

Handling of Pregnant Rats: Effects on Emotionality of Their Offspring

Abstract. *Pregnant rats were either unmanipulated or were handled for 10 minutes three times daily throughout pregnancy. Offspring remained with their natural mothers or were cross-fostered within and between experimental and control groups. When tested at 45 and 100 days of age, the offspring of handled mothers were found to be generally less emotional than the controls.*

By using conditioning techniques, it has been shown that prenatal maternal "anxiety" increases offspring emotionality in the rat (*1, 2*). The effects which might obtain from other types of behavioral treatment of a pregnant animal are not known. Various manipulations, notably "handling," decrease emotionality in the rat when administered postnatally. The present study, then, was designed to determine the effects of prenatal handling, that is, handling of the pregnant animal, on emotionality of the offspring.

Data were obtained from a total of 138 offspring of primiparous Sprague-Dawley rats. These females were placed with males each evening and pregnancy was determined by vaginal smears taken the following morning. By random selection, half the pregnant animals remained unmanipulated and half were handled for 10 minutes three times daily (once each morning, afternoon, and evening) throughout the period of gestation. Pregnant animals were group-housed until approximately 1 week before delivery when they were individually placed into nesting cages. Handling consisted of picking up the animal and holding it loosely in one hand.

Litters were culled to seven or eight pups within 48 hours of birth and cross-fostering was also accomplished within this time. An equal number of litters remained with their natural mothers, were cross-fostered to mothers of that same group, or were cross-fostered to mothers of the opposing group. After this time the nesting cages in which the animals were housed were not cleaned and the pups were not manipulated in any way until weaning at 21 days. After weaning, animals were segregated by sex and treatment, and group-housed in standard laboratory cages. Food and water were available at all times.

Approximately half the animals were tested for emotionality at 45 days and 120 animals were tested at 100 days in an open-field situation. The field was 5 ft (1.5 m) in diameter and marked off into 7.5-inch (19-cm) squares and four concentric circles. Behaviors recorded were squares traversed and entries into the inner concentric circles (inversely related to emotionality), and defecation (directly related to emotionality). At 100 days all animals were also observed in an emergence-from-cage test in which the time required by animals to emerge from their open home cage (directly related to emotionality or "timidity") was recorded up to a maximum of 900 seconds.

Beginning at weaning a biweekly record of body weight was kept for 13 weeks. These data indicated no difference in the absolute weight or rate of growth between the prenatally handled and control animals.

Taken together, the emotionality data did not reveal any consistent tendency for animals fostered to handled mothers to differ from those fostered to control mothers. The data obtained from the open-field are given in Table 1. An analysis of variance applied to squares traversed revealed no differences as a function of group, sex, fostering, previous experience in the field, or any interaction of these. Inspection of the data on the percentage of animals entering inner circles did not suggest the presence of any interactions within either the 45- or 100-day tests. Chi-square analyses indicated that a somewhat larger percentage of the combined offspring of handled mothers approached the center of the field at 100 days, but not on the earlier test.

Table 1. Open-field behavior in prenatally handled (H) and control (C) offspring.

Group	Squares traversed (mean No.)	Animals entering inner circles (%)	Animals defecating (%)
	Test age 45 days		
H (N = 28)	25.6	14.3	17.9
C (N = 30)	29.5	16.7	63.3
p	> .10	> .10	< .01
	Test age 100 days		
H (N = 59)	25.2	45.8	20.3
C (N = 61)	23.2	27.9	45.9
p	> .10	< .10	< .01

Defecation in the open-field also showed no interaction effects. Within each subgroup of handled and control offspring at both 45 and 100 days, an equal or greater number of control offspring relative to handled offspring defecated. Chi-square analyses indicated that the number of prenatally handled animals defecating in the field was significantly lower than the number of control offspring on both tests ($\chi^2 = 10.54$; $\chi^2 = 7.71$).

The F test showed a significant Group × Fostering interaction on the

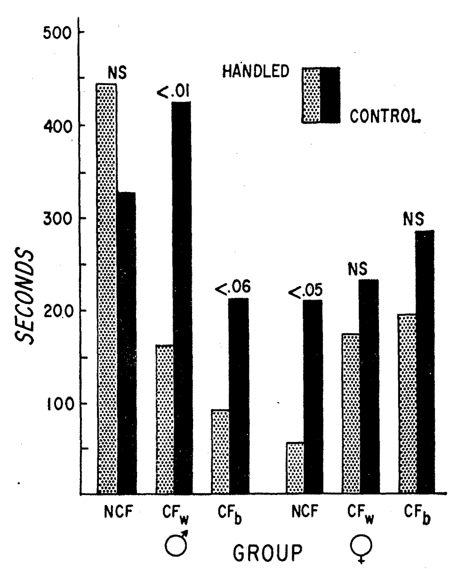

Fig. 1. Mean time required by prenatally handled and control offspring to emerge from their home cage (NCF = non-cross-fostered; CF_w = cross-fostered within group; CF_b = cross-fostered between groups).

emergence-from-cage test. Among males there was no difference between the non-cross-fostered handled (N = 7) and control (N = 10) groups, whereas both cross-fostered groups of prenatally handled animals (N = 11 and 20) emerged significantly sooner than controls (N = 10 and 12). Among females it was the cross-fostered groups (N = 13 and 11 for handled and 10 and 9 for control animals) which did not differ significantly, but the non-cross-fostered offspring of handled mothers (N = 12) emerged significantly sooner than controls (N = 13). These data are presented in Fig. 1.

In contrast to the greater offspring emotionality effected by prenatal maternal "anxiety," prenatally handled animals appear to be less emotional than controls. To the extent that high emotionality may be considered maladaptive, such results serve to contradict any orientation or expectation that only deleterious effects can result from prenatal manipulation.

It has been hypothesized by Thompson (*1*) that the behavioral effects of prenatal maternal manipulations are brought about by the hormonal changes which occur in the mother in response to the anxiety-provoking stimulation. Presumably, these changes are transmitted to the fetus via the maternal-fetal blood exchange. If such are the mediating mechanisms, it would follow from the present data that the response of the pregnant (or for that matter, the nonpregnant) animal to handling is qualitatively and/or quantitatively different from the response to some if not all other forms of "stressful" stimulation of the kind commonly used in studies of environmental influences on behavior. Such a hypothesis has implications for the design of research on the effects of "early" as well as prenatal experiences since it would appear that one cannot necessarily generalize from the effects of one type of manipulation to another. Unfortunately, little is known at this time about the psychophysiological responses concomitant with handling or other behavioral manipulations (*3*).

ROBERT ADER
PETER M. CONKLIN

Department of Psychiatry,
University of Rochester
School of Medicine and Dentistry,
Rochester 20, New York

References and Notes

1. W. R. Thompson, *Science* **125**, 698 (1957).
2. R. Ader and M. L. Belfer, *Psychol. Rept.* **10**, 711 (1962); G. Doyle and E. P. Yule, *Animal Behav.* **7**, 18 (1959); C. H. Hockman, *J. Comp. Physiol. Psychol.* **54**, 679 (1961).
3. Supported by grant MH 03655 from the National Institute of Mental Health.

23 August 1963

Prediction of Discrimination from Generalization after Variations in Schedule of Reinforcement

Abstract. *The relationship between generalization and discrimination is explored in the present study by utilizing the results of systematic changes in the generalization gradient to predict changes in discrimination behavior. In the first of two experiments, differing groups of pigeons were trained to respond to a wavelength of 550 mμ under conditions of varying schedules of reinforcement. Generalization gradients were then obtained and the ratios of the responses to selected discriminative stimuli calculated. These were used to predict discrimination behavior in a second experiment using the same stimuli. Both the number of trials to a discrimination criterion and the ratio of response indicate the plausibilty of an inverse hypothesis, and the applicability of the generalization model to related behavior such as discrimination.*

Several investigators (*1–3*) have explored the relationship between generalization and discrimination. In one such study, Guttman and Kalish (*1*) hypothesized an inverse relationship between generalization and the discrimination function for wavelength of light in pigeons (delta lambda function). Gradients obtained after training, however, did not show the anticipated changes corresponding to variations in the delta lamdba function. Kalish (*2*), on the other hand, obtained the expected relationship between generalization and the discrimination function for human subjects.

Other studies have also attempted to demonstrate the extent to which variables commonly associated with generalization testing procedures have produced changes in the generalization gradient. Such changes may involve the elimination of cues which maximize discrimination during generalization testing.

Kalish and Haber (*3*), for example, compared gradients from generalization testing to single and multiple stimuli. The gradient obtained with the single stimulus procedure was flatter than that from the multiple stimulus method. The concave form of the mutliple stimulus gradient compared to the linear form of single stimulus gradient suggested the presence of a discrimination process during generalization testing.

An alternative method of testing the inverse hypothesis would involve generating systematic changes in generalization and using the obtained generalization gradients as models to predict discrimination behavior. If systematic changes corresponding to steepening of the gradient for one level of a variable and flattening for the other could be obtained, the gradients thus generated could be used as models for predicting subsequent behavior in a discrimination task. Varying the number of reinforcements during training suggests one possible way to achieve these changes in the gradient.

Two separate experiments were conducted following the preceding plan. The first one explored changes in generalization along the wavelength continuum as a function of schedules of reinforcement. Subjects were trained to respond to 550 mμ under different schedules of variable-interval reinforcement. Predictions concerning discrimination between certain selected points on the wavelength continuum were made from the subsequent generalization gradient. A new group of birds was then trained to 550 mμ under precisely the same schedules of reinforcement employed in the first experiment, and, after 10 days of training, these birds were required to form a discrimination between 550 to 540 or 540 to 530 mμ.

The subjects were 54 experimentally naive, white, Carneau pigeons reduced to 80 percent of their free-feeding weight. Eighteen birds were used for the first experiment, and 36 for the second.

After the 18 birds in the first experiment were reduced to 80 percent of their free-feeding weight they were trained by the method of successive approximations to peck at a plastic disk illuminated by a wavelength of 550 mμ. They were then placed in one of three reinforcement groups (mean intervals 15 seconds, 1 minute, and 4 minutes) and given 30 minutes of variable-interval training each day for a period of 10