Strain differences of mice in response to the shock-situation: Measurements of the post-stress activity rhythms and the body weight change¹

KENJI OMATA and KEIICHIRO TSUJI²

Department of Psychology, Faculty of Letters, Nagoya University, Chikusa-ku, Nagoya 464

Two experiments were conducted to investigate the long-term effects of stress upon responses in inbred mice, C57BL/6J and CS. In Experiment I, the mice received intermittent electric shocks for five hours in a day for 15 days. Activity rhythms and the body weight were measured in the home cage, and locomotion and the body weight loss in the shock box. In the C57BL/6J mice, the body weight decreased over days, while the body weight loss in the shock box decreased. Activity rhythms did not change remarkably. In the CS mice, the body weight remained constant, although the weight loss was larger in the stress situation and the drinking activity rhythm changed. Experiment II revealed that this change in drinking activity rhythm was due to the experimental manipulation other than E.S. The relationship between post-stress behaviors and the body weight change was discussed.

Key words: stress, activity rhythm, body weight, strain difference, mice.

Recent psychological studies on stress effects have been concerned with the problems of predictability and controllability (Imada, 1971; Miller, 1980; Tsuda & Hirai, 1976a; Tsuda, 1978; Weiss, 1977). These studies have revealed that physiological reactions or pathological symptoms as indicators of stress depend not only on the amount of aversive stimulation but also on the psychological variables mentioned above.

However, when we turn to the question of how animals adapt to the stress situation, the following problems can be pointed out regarding the studies so far conducted.

Firstly, investigators were mainly concerned with animals' reactions in acute stress situations where a subject received strong aversive stimulus (stressor) frequently for comparatively short period of time (e.g., Tsuda & Hirai, 1976b; Weiss, 1970).

¹ Experiment I of this study was reported at the 46th Annual Convention of the Japanese Psychological Association, 1982.

² The authors are very much indebted to Dr. Tasaku Tsunoda, Associate Professor of Linguistics, Faculty of Letters, Nagoya University for his help in preparing an English version of the paper.

This procedure successfully and easily produced symptoms of interest to the investigators. It is, however, questionable whether the psychological mechanisms found there correspond to those in a chronic situation. Thus, studies on the psychological effects of chronic stress are required to clarify the adaptive process in a stress situation.

Secondly, the investigators have not paid enough attention to the behaviors which occurred after a stressor was removed. However, studies on these behaviors will provide valuable information, since they may have an adaptive significance. The effects of stress on the physiological responses were found to continue even after the stressor had been removed (Frankenhaeuser, 1978; Ogawa & Inamori, 1971) and physiological compensation occurred against physiological exhaustion caused by repetitive exposures to the stress (Weiss, Clazer, Pohorecky, Ba, & Miller, 1975). In addition, it is also conceivable that the post-stress situation may have an important role as a recovery phase.

Thirdly, only operant behaviors against stressor have been investigated in previous studies (e.g., Berger, Starzec, Mason, &

Devito, 1980; Goeling, Buchholz, & Carrera, 1974; Tsuda & Hirai 1975; Weiss, 1971). However, stress situation may be considered as a sort of problem-solving task, and a subject has to make efforts to escape from it. Thus a variety of background behaviors may also have some adaptive significance as well as specific responses directly caused by a stressor. In spite of this possibility, few behavioral studies have dealt with multidimensional measures, except for the study on aggressive behavior by Weiss, Pohorecky, Salzman, and Gruenthal (1976).

In the present study, behaviors of mice were observed both in stress and post-stress situations over a long term. Diurnal activity rhythms and body weight were of primary interest, because the former seems to show a basic adaptive pattern and the latter is used as a physiological indicator of stress symptom (e.g., Conger, Sawrey, & Turrel, 1958; Paré, 1964; Weiss, 1970).

Inbred mice of two strains, C57BL/6J and CS, were compared on these responses. These two strains were found to be different in the diurnal rhythms of wheel-running, drinking and eating (Ebihara & Tsuji, 1976; Tsuji, Ebihara, & Ohkouchi, 1982), and other kinds of behavior.

Experiment I

Method

Subjects. The subjects were inbred male mice of two strains, C57BL/6J and CS. They were 90–120 days old at the start of the experiment and were experimentally naive. The numbers of the subjects for C57BL/6J and CS were ten and eight respectively.

Apparatus. Each mouse was housed individually in the acrylic cage (17.5 cm × 24.5 cm × 12.5 cm) with a running wheel on its top. This was the same cage as that used by Ebihara and Tsuji (1976). The only exception was that a wire-

meshed plate (11 cm × 9 cm × 0.7 cm) was placed under the water bottle so as to record drinking activity. When a mouse licked the water tube, relay circuit was closed and event recorder was set up in motion. Wheel-running activity was recorded by UT-403 time counter (Unitec Electronics) and printed out every one hour.

Shock box was made of acrylic resins measuring 15 cm × 20 cm × 20 cm. Number of locomotion was counted when a mouse crossed the beam set on the side walls of the shock box. The floor of the box consisted of the brass grids 0.5 cm apart from each other, through which electric shock was delivered to the mouse.

The experimental room was partitioned into two corners and the shock box was placed in the different corner from that of the home cage.

Procedure. Experiment I consisted of the following four sessions.

(i) Pre-experimental session (15–20 days): The mice were isolated individually in the acrylic cages mentioned above at the start of the experiment. Lighting cycle of 12L(6:00–18:00)–12D(18:00–6:00) was introduced and continued throughout the experiment. Thus, the mice were required to rehabilitate to the new home cages as well as to regulate their activity rhythms to the new lighting cycle.

(ii) Base session (4 days): Conditions were the same as those of the pre-experimental session except that the wheel-running, drinking and the body weight were additionally measured. Two behaviors were recorded over 24 hours on the 1st and the 3rd days, while the body weight was measured at 17:00 every day.

(iii) Habituation session (4 days): Each mouse was taken out of the home cage and placed in the shock box at 17:00 and left there until 22:00 every day. Although the four hours from 18:00 were within dark phase under the normal living condition in the home cage, the in-

terior of the shock box was dimly lit at approximately 15 lx. The mouse was allowed to explore the box where no shock was given during this session. The number of locomotion was counted. The mice were treated in the same way as before after they were returned to their home cage.

The behavior measurements were done on the 1st and 3rd days of this session. The body weight was measured twice every day, at 17:00 and 22:00. The change in the body weight while staying in the shock box was calculated in terms of the percentage of body weight loss; $[(\text{body weight at 17:00} - \text{body weight at 22:00}) / \text{body weight at 17:00}] \times 100$.

(iv) Stress session (15 days): The only difference from the session (iii) was that the mouse received electric shock in the shock box. Five-hours in the shock box was divided into five shock periods and four non-shock periods. Shock periods had different duration (30, 45, 45, 45, and 75 min) and were given in a random order intervened by non-shock period of 15 min duration. An electric shock was 1.3 mA in intensity and 1 s in duration. Shocks were given intermittently with 15 s and 35 s intershock intervals alternately provided during the shock periods.

Measurement was done in the same way as in the habituation session.

Scoring of drinking activity. Actual number of drinking was not obtained, since the drinking activity was recorded by a pen-writing event recorder running at the speed of 10 mm/h so as to make the rhythmicity easily observable. Therefore, the length of pen's oscillation was measured and scored one point for every 0.5 cm. Diurnal rhythm of drinking was depicted on this score. Daily amount was a total sum of the day.

Results and Discussion

Base session. (i) Diurnal activity rhythms: Diurnal rhythms of wheel-running and drinking are shown in Fig. 1.

They showed typical nocturnal patterns in both strains. They showed biphasic enhancement of activity during the dark phase. This result is consistent with previous findings (Tsuji et al., 1982).

(ii) Daily amount of drinking and body weight: The analysis of variance of Strain $\times$ Day on the body weight revealed significant main effects of Strain ($F=17.29$, $df=1/16$, $p<.01$) and Day ($F=5.70$, $df=1/16$, $p<.05$). C57BL/6J weighed more than CS and the body weight increased from the 1st to the 3rd day in both strains. No significant effect was found regarding the drinking data.

Habituation session. (i) Diurnal activity rhythms: Both activities during the first half of light phase increased. Those of the 1st and the 3rd days significantly differed from those of the 3rd day of the base session at the level of $p<.05$ in both strains (t -test). Other remarkable changes were not found.

(ii) Daily amount of drinking and

Fig. 1. Rhythms of wheel-running and drinking activities during base session in two strains of mice. The term of "Base 3" in the figure indicates the 3rd day of the base session.

Fig. 2. Rhythms of wheel-running activity in two strains of mice during habituation and stress sessions. Because subjects are removed from their home cage from 17:00 to 22:00, the number of revolution was recorded as zero during this five hours.

body weight: The analysis of variance on the body weight revealed significant main effect of Strain ($F=14.63$, $df=1/16$, $p<.01$). No difference in body weight was observed between this session and previous session. As to drinking, significant increase was found between the 3rd day of the base session and the 1st day of the habituation session ($t=2.875$, $df=7$, $p<.01$), but other effects were non-significant.

(iii) Number of locomotion and the body weight loss during the five hours in the shock box: Both locomotion and the loss of body weight decreased as days proceeded. Significant main effect of Day was found both in locomotion ($F=5.75$, $df=1/16$, $p<.05$) and in the body weight loss ($F=7.74$, $df=1/16$, $p<.025$). Significant main effect of Strain was found in locomotion ($F=9.88$, $df=7/105$, $p<.01$), C57BL/6J locomoting more than CS.

Stress session. (i) Diurnal activity rhythms: As shown in Fig. 2, both strains

maintained basically same activity rhythm of wheel-running as that of the preceding session. Drinking activity rhythm, however, changed in this session, especially in CS (Fig. 3). C57BL/6J maintained rhythm pattern observed in the preceding session except for the 1st day, while activity rhythm of CS became entrained less to the lighting cycle as the day progressed. Remarkable change was found during the first half of light phase (6:00–12:00). Then, the percentage of drinking score during this time was examined.³ As shown in Fig. 4, that of CS gradually increased and significant difference was found between the 15th day of this session and the 3rd day of the preceding session ($t=5.541$, $df=7$, $p<.001$). In C57BL/6J, significant difference was found between

³ Because of missing data, statistical analysis on this measure was made on the 1st, 7th, 11th, and 15th days.

Fig. 3. Rhythms of drinking activity in two strains of mice during habituation and stress sessions. Because of missing data, each number of subjects was seven on the 3rd and 9th days in CS, and seven on the 13th day in C57BL/6J. As to the five hours from 17:00 to 22:00, refer to the explanation in Fig. 2.

the 1st day of this session and the 3rd day of the preceding session ($t=2.658$, $df=9$, $p<.05$), but not on the following days. This strain difference in the daily change more clearly appeared, when the percentage of drinking score for four hours (8:00–12:00) during which both strains rarely drank in the base session were examined. Analysis of variance on this measure revealed significant interaction effect of Strain $\times$ Day ($F=3.049$, $df=3/48$, $p<.05$).

(ii) Daily amount of drinking and body weight: Both of these measures are shown in Fig. 5. Comparison between the 1st day of the stress session and the 3rd day of the base session revealed significant decrease of the body weight in C57BL/6J ($t=3.611$, $df=9$, $p<.01$). As shown in Fig. 5, the amount of drinking gradually increased over days in both strains. The analysis of variance of Strain $\times$ Day reveal-

Fig. 4. Daily changes of the percentage of drinking score during the first half of light phase. The percentage was calculated by the following formula: sum of the drinking scores during six hours from 6:00 to 12:00 / daily amount of drinking score $\times 100$.

Fig. 5. Changes of daily amount of drinking and body weight as a function of experimental session.

ed significant main effect of Day ($F=3.18$, $df=3/48$, $p<.05$). Changes in the amount of drinking and the body weight, however, did not show the expected parallelism. The analysis of variance of Strain $\times$ Day on the body weight revealed significant main effect of Strain ($F=4.62$, $df=1/16$, $p<.05$) and interaction of Strain $\times$ Day ($F=5.26$, $df=7/112$, $p<.01$). That is, the body weight of CS maintained the level of the preceding session but C57BL/6J lost its body weight over days.

(iii) Number of locomotion and the body weight loss in the shock box: The number of locomotion in the shock box decreased rapidly from the 1st day to the 5th day and remained relatively unchanged throughout the rest of this session in both strains. The analysis of variance of Strain $\times$ Day revealed significant main effect of Day ($F=13.95$, $df=7/105$, $p<.01$).

As to the percentage of body weight loss during the five hours in the shock box (Fig. 6), both strains showed significantly greater amount of body weight loss on the 1st day than the 3rd day of the preceding session ($t=2.867$, $df=9$, $p<.025$ in C57BL/6J and $t=4.029$, $df=7$, $p<.005$ in CS). The analysis of variance of Strain $\times$ Day revealed that both main effects and the

interaction effect were significant ($F=15.1$, $df=1/16$, $p<.01$ for the Strain effect, $F=7.18$, $df=7/112$, $p<.01$ for the Day effect and $F=2.30$, $df=7/112$, $p<.05$ for the interaction effect). As shown in Fig. 6, CS showed larger amount of body weight loss throughout the session but C57BL/6J showed decrease in this measure.

The above results revealed clear strain differences in response to stress situation. In the behavioral aspect, CS changed its

Fig. 6. Percentage of the body weight loss in shock box.

diurnal rhythm of drinking by weakening the entrainment to the light, while C57BL/6J did not. As to the body weight, C57BL/6J did not recover sufficiently for the subsequent 19 hours after stress. CS, on the other hand, recovered completely within a day (Fig. 5). Such a difference in body weight was not attributable to the difference in the sensitivity to E.S. CS seemed to be more reactive to E.S. than C57BL/6J as far as the body weight loss in the shock box were concerned. It might, however, be possible to attribute the delay of recovery of body weight in C57BL/6J to the decrease in food intake. It is impossible to assess this possibility because of the lack of data on food intake. But following results discourage this interpretation. There were no differences between the base and stress sessions in the daily amount of drinking which is known to be highly correlative with food intake (Oma-

ta & Tsuji, 1983; Tsuji et al., 1982), yet changes in the body weight and drinking did not correspond to each other (Fig. 5).

However, the interpretation of these strain differences becomes equivocal when the following problems are taken into consideration. First, the mice were placed in the shock box from 17:00 to 22:00 when eating and drinking usually appear most vigorously and deprived of food and water. Second, placing mice in the dimly-lit shock box actually extended the light phase until 22:00. Therefore, these factors might have differential effect upon each of the two strains. Strain differences found in previous researches make this possibility more probable. Thus, the effects of these extraneous factors were investigated in the following experiment.

Fig. 7. Rhythms of wheel-running activity during base and control sessions in two strains of mice. As to the five hours from 17:00 to 22:00 of control session, see Fig. 2.

Fig. 8. Rhythms of drinking activity during base and control sessions in two strains of mice. As to the five hours from 17:00 to 22:00 of control session, see Fig. 2.

Experiment II

The aim of this experiment was to see whether the above-mentioned external variables other than E.S. had any effect upon the data obtained in Experiment I. The same procedure except for the administration of E.S. was replicated. Thus, the present experiment serves as a control for Experiment I.

Method

Subjects and apparatus. Animals were experimentally naive male inbred mice from the two strains of C57BL/6J and CS. Five mice of each strain were used. C57BL/6J mice were 90–110 days old and CS mice were 100–140 days old at the start of experiment.

Home cage and shock box were the same as those used in Experiment I.

Procedure. After habituating to the home cage for 7–10 days, the mouse received the same procedure as in the base session of Experiment I for four days. The mouse was then placed in the shock box from 17:00 to 22:00. This session lasted for fifteen days. Behaviors and the body weight were recorded in exactly the same way as in Experiment I.

Results and Discussion

Base session. (i) Diurnal activity rhythms: Diurnal rhythms of wheel-running (Fig. 7) and drinking (Fig. 8) were clearly nocturnal, showing patterns similar to those observed in Experiment I.

(ii) Daily amount of drinking and body weight: These measures proved stable in this session. The analysis of variance of Strain $\times$ Day was not significant. The result differed from that of Ex-

periment I in that no strain difference was found in the body weight. This discrepancy might be attributed to the fact that CS mice in this experiment were older than those in Experiment I.

Control session. (i) Diurnal activity rhythms: Both wheel-running (Fig. 7) and drinking (Fig. 8) of C57BL/6J maintained nocturnal rhythms throughout this session, while CS changed them. CS came to drink and run at the early stage of light phase. The percentage of drinking during the first half of light phase of CS gradually increased day by day. Significant differences were found between the 3rd day of the base session and both of the 11th and the 15th day of this session ($t=4.398$, $df=4$, $p<.02$ on the 11th day and $t=7.712$, $df=4$, $p<.01$ on the 15th day). Analysis of variance of Strain $\times$ Day on this measure revealed significant Strain effect ($F=12.340$, $df=1/8$, $p<.01$) and interaction effect ($F=3.536$, $df=3/24$, $p<.05$). The percentage of wheel-running during the first half of light phase was significantly different from that of the 3rd day of the base session at the level of $p<.05$ all days but the 7th day in CS.

(ii) Daily amount of drinking and body weight: Figure 9 shows daily changes in the amount of drinking and body weight. While the CS mice drank as much

as in the base session, the amount of drinking in C57BL/6J gradually decreased. For C57BL/6J, a significant difference was found between drinking score of the 3rd day of base session and that of the 15th day of the control session ($t=6.779$, $df=4$, $p<.005$). The analysis of variance of Strain $\times$ Day for the drinking data revealed significant interaction effect ($F=3.21$, $df=3/24$, $p<.05$).

C57BL/6J maintained the body weight of base session, while CS increased its weight gradually up to the level significantly greater than that on the final day of base session ($t=3.492$, $df=4$, $p<.05$). The analysis of variance of Strain $\times$ Day revealed significant interaction effect ($F=9.75$, $df=7/56$, $p<.01$).

The two measures changed in a parallel fashion in both strains, as indicated in Fig. 9.

(iii) Number of locomotion and the body weight loss in the shock box: Number of locomotion in the shock box gradually decreased in both strains. As for the percentage of the body weight loss, C57BL/6J showed greater body weight loss than CS for the early stage of this session ($t=2.528$, $df=64$, $p<.025$, on the 1st day; $t=2.515$, $df=64$, $p<.025$, on the 3rd day). However, the amount of weight loss rapidly decreased and became stable at the same level as CS during the rest of the session. The analysis of variance of Strain $\times$ Day revealed both main effects and interaction to be significant ($F=2.24$, $df=1/8$, $p<.05$ for Strain effect; $F=16.46$, $df=7/56$, $p<.01$ for Day effect; $F=7.15$, $df=7/56$, $p<.01$ for interaction effect).

The above results indicate that the procedure of moving mice into the shock box from their home cage causes different effects on their behaviors in the home cage between strains. CS was more easily affected. The daily stability of body weight suggests that the body weight recovers within a day in both strains. Close parallelism of drinking amount and the body weight (Fig. 9) suggests that the body

Fig. 9. Changes of daily amount of drinking and body weight during base and control sessions.

weight was determined by the amount of water intake which correlated with food intake (Omata & Tsuji, 1983; Tsuji et al., 1982). Furthermore, locomotion and the body weight loss in the shock box indicate the rapid habituation to the box, if no shock was delivered.

General Discussion

As discussed above, Experiments I and II demonstrated some differences in behavior and body weight changes between CS and C57BL/6J. The main results of this study are discussed briefly.

Activity rhythm of drinking became blurred in CS, while no comparable change was found in C57BL/6J. The blurred rhythm of CS in Experiment I should be attributed to the effect of external variables involved in the procedure, since the change was observed with the mice in Experiment II as well. Food- and water-deprivation for five hours might have been responsible for making the rhythm of CS blur, judging from the fact that the change in rhythm more clearly appeared in drinking than wheel-running.

As for two measures of body weight, strain differences in Experiment I could be attributed to the differential effects of E.S. between two strains, since Experiment II failed to reveal these strain differences.

These findings of this study provide some interesting problems for the stress researches. Firstly, most of the previous investigations attempted to deal with the effect of a stressor only in the situation where it was administered, e.g., in the shock box in this study. The results of this study, however, indicate that the responses in such a restricted situation do not necessarily correspond to those in the post-stress situation, as far as the body weight was concerned. Immediate effect of E.S. was stronger in CS than in C57BL/6J; the former showed larger amount of the body weight loss in the shock box. Nevertheless,

recovery of the body weight in the home cage was slower in the latter. Undoubtedly, it remains to be clarified how these body weight changes correlate with other kinds of stress responses. Previous studies demonstrated that the body weight loss tended to accompany pathological symptoms or endocrinological changes (e.g., Berger et al., 1980; Conger et al., 1958; Weiss et al., 1975). Although these kinds of internal changes were not examined, the body weight change obtained here might have reflected changes in the physiological state.

Secondly, the behavioral changes in the post-stress situation could be discussed from the viewpoint of adaptive significance. In CS, the drinking activity rhythm became less entrained to lighting cycles in response to the experimental manipulation. The residual effect lasting after release from E.S. vanished within a day, as far as recovery of the body weight was concerned. This rapid recovery might be attributable to flexibility of the drinking activity rhythm in this strain. Since eating activity has been found to show the close parallelism with drinking, it probably accompanied the heightened drinking activity in the light phase in this study. Such change in activity rhythms seem to enable nutrition enough to compensate for the physiological exhaustion. Contrary to this, such a compensatory process does not seem to occur in C57BL/6J, since no remarkable change in behavior were not observed.

Needless to say, our interpretation is a tentative one and needs to be reconfirmed by further experiments. One way to do this will be to examine behavioral and physiological responses using different stressors. These studies will clarify both the differential effects produced directly by a stressor and the behavior characteristics in the post-stress situations. Thus, it will be possible to obtain wider perspectives of the adaptive mechanisms in a stressful situation.

References

- Berger, D. F., Starzec, J., Mason, E. B., & Devito, W. 1980 The effects of differential psychological stress on plasma cholesterol levels in rats. *Psychosomatic Medicine*, **42**, 481-492.
- Conger, J. J., Sawrey, W. L., & Turrel, E. S. 1958 The role of social experience in the production of gastric ulcers in hooded rats placed in conflict situation. *Journal of Abnormal and Social Psychology*, **57**, 214-220.
- Ebihara, S., & Tsuji, K. 1976 Strain differences in the mouse's wheel-running behavior. *Japanese Psychological Research*, **18**, 20-29.
- Frankenhaeuser, M. 1978 Psychoendocrine approaches to the study of emotion as related to stress and coping. In H. E. Howe Jr. & R. A. Dienstbier (Eds.), *Nebraska symposium on motivation*. Lincoln / London. University of Nebraska Press. Pp. 123-162.
- Goesling, W. J., Buchholz, A. R., & Carrera, C. J. 1974 Conditioned immobility and ulcer development in rats. *Journal of General Psychology*, **91**, 231-236.
- Imada, H. 1971 Experimental studies on pathological behavior in animals. *Japanese Psychological Review*, **14**, 3-27. (In Japanese)
- Miller, N. E. 1980 Effects of learning on physical symptoms produced by psychological stress. In H. Selye (Ed.), *Selye's guide to stress research*. New York: Van Nostrand Reinhold Comp. Pp. 131-167.
- Ogawa, T., & Inamori, Y. 1971 Sympathetic influences on restraint ulcer. *Journal of Japanese Psychosomatic Society*, **11**, 17-22. (In Japanese)
- Omata, K., & Tsuji, K. 1983 Changes in activity rhythms in inbred mice during repeated food-deprivation. *Annual of Animal Psychology*, **33**, 27-42. (In Japanese)
- Paré, W. P. 1964 The effect of environmental stress on stomach ulceration, adrenal function, and consummatory behavior in the rat. *Journal of Psychology*, **57**, 143-151.
- Tsuda, A. 1978 Application of learning and behavior theory to the development of gastric lesions. *Japanese Journal of Psychosomatic Medicine*, **18**, 142-148. (In Japanese)
- Tsuda, A., & Hirai, H. 1975 Effects of the amount of required coping response task on gastrointestinal lesions in rats. *Japanese Psychological Research*, **17**, 119-132.
- Tsuda, A., & Hirai, H. 1976a Pathological stress and development of gastric lesions in animals. *Japanese Psychological Review*, **19**, 116-139. (In Japanese)
- Tsuda, A., & Hirai, H. 1976b Effects of signal-shock contingency probability on gastric lesions in rats as a function of shock region. *Japanese Journal of Psychology*, **47**, 258-267. (In Japanese)
- Tsuji, K., Ebihara, S., & Ohkouchi, O. 1982 Strain differences in drinking and eating activities of the inbred mice. *Tohoku Psychological Folia*, **XXXI**, 1-4.
- Weiss, J. M. 1970 Somatic effects of predictable and unpredictable shock. *Psychosomatic Medicine*, **32**, 397-408.
- Weiss, J. M. 1971 Effects of coping behavior in different warning signal conditions on stress pathology in rats. *Journal of Comparative and Physiological Psychology*, **77**, 1-13.
- Weiss, J. M. 1977 Psychosomatic disorders: Psychological and behavioral influences on gastrointestinal lesions in animal models. In J. D. Maser & M. E. P. Seligman (Eds.), *Psychopathology: Experimental models*. San Francisco: W. H. Freeman and Company. Pp. 232-269.
- Weiss, J. M., Glazer, H. I., Pohorecky, L. A., Ba, J. B., & Miller, N. E. 1975 Effects of chronic exposure to stressors on avoidance-escape behavior and on brain norepinephrine. *Psychosomatic Medicine*, **37**, 522-534.
- Weiss, J. M., Pohorecky, L. A., Salman, S., & Gruenthal, M. 1976 Attenuation of gastric lesions by psychological aspects of aggression in rats. *Journal of Comparative and Physiological Psychology*, **90**, 252-259.

(Received April 13, 1983; accepted
Nov. 19, 1983)