EFFECTS OF THE AMOUNT OF REQUIRED COPING RESPONSE TASKS ON GASTROINTESTINAL LESIONS IN RATS

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The effects of the coping response on gastrointestinal lesions by changing the values of fixed-ratio (FR) schedule for the coping response task in free-operant avoidance situation over 24 hrs were studied. In FR 1 or FR 2, experimental animals which could control electric shock to avoid or escape by pushing a flapper only once or twice developed less severe gastrointestinal lesions and body weight loss than yoked animals which received the same amount of shocks but could not perform any coping responses. In FR 5 or FR 8, however, the experimental Ss developed more severe stress pathology than the yoked or control Ss. These reversal effect show that the interaction between controllability of experimental environment and the amount of required coping response task plays an important role, which seems to support Weiss’s ulcer-prediction model.

It is well known that “psychosomatic” diseases, such as gastric ulcers, essential hypertension and coronary heart disease are related to emotional stress (anxiety, fear or conflict). Many studies have been conducted to clarify the relationships between psychological stress and gastrointestinal ulcers in animals.

Brady (1958) and Porter, Brady, Conrad, Mason, Galambos, and Riech (1958) previously reported that the experimental animal, or the “executive” monkey, who could avoid an electric shock by pressing a lever under Sidman avoidance schedule, developed duodenal ulceration, and that the control animal which received identical shock experiences developed no ulceration. Brady and his coworkers concluded that responsibility for the fulfillment of the lever-pressing shock termination produces gastroduodenal ulcers while shock alone does not.

However, the validity of Brady’s experiment could be questioned. First, the monkeys were not randomly assigned to experimental and yoked control groups. In each pair, the subject which acquired the avoidance response first was chosen as the executive. Such a method of selection was not proper according to Sines, Cleeland and Adkins (1963) who found that rats which were susceptible to ulcers learned an avoidance response faster than normal controls. Second, in Brady’s experiment the ulcer was produced only under the condition in which the monkeys worked on a cycle of an alternating six-hour avoidance and six-hour rest schedule. Animals exposed to either a 1 hr or 3 hr work-rest schedule did not develop ulcers. Third, some investigators who had attempted to replicate Brady’s results have...
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not been successful (Folts & Millett, 1964; Paré, 1971).

In addition, experiments done by Weiss (1968, 1971 a, b, c) showed contradictory results to Brady and his associates’ in which rats performing an avoidance and/or escape response from electric shock developed less severe physiological symptoms of stress (weight loss, stomach ulcers, and defecation) than yoked subjects which received the same number of shocks but could not avoid or escape shocks. Weiss (1968) has labelled these instrumental responses as “coping responses.” Moot, Cebulla, and Crabtree (1970) also reported that fewer animals which were able to terminate the aversive stimulus by means of an instrumental escape response developed stomach ulcers than did animals with inescapable shocks. Miller (1969, 1972) interpreted the discrepant results between Brady and Weiss as follows: “With a very easy task, being able to perform a coping response reduces the stress, but perhaps, as the task becomes too difficult, performing it increases the stress.”

In the present study whether subjects that could avoid or escape aversive events by performing an easier task developed less severe gastric lesions than subjects with a more difficult coping task, was investigated. The difficulty of a coping task probably might have a functional relationship with the number of responses required to terminate the shock. Should it be the case, an easy task condition is defined as performing the flapper-pushing response only once to avoid or escape shocks, as opposed to a hard task which is defined as performing eight responses to obtain the same effect. In the present investigation, we examined the relationship between the amount of a required coping task and psychosomatic syndromes.

Another purpose of this experiment was to examine the reliability and validity of Weiss’s predictive ulcer model (Weiss, 1971a; and see Weiss, 1972a, b, for reviews). Weiss has stated that ulceration will increase as (a) the number of coping attempts increases and (b) the amount of relevant feedback decreases, so that ulceration will be severe when responding is high and relevant feedback is low, and will be progressively less severe as responding decreases and relevant feedback increases. But, there have been no studies, to the present authors’ knowledge, that have investigated Weiss’s predictive model from the behavioral point of view. Only Barbaree and Harding (1973) suggested that a free-operant avoidance schedule generating a high response rate and low shock destiny was ulcerogenic. Tsuda and Yamanaka (1974), as well as Tsuda, Hirai, and Yamanaka (1974) have dealt with predictability and controllability of electric shock by alternating response-shock (R-S) interval, which might control the rate of response. They revealed its effect on stomach lesions and bodily changes.

In the present study, the effects of four different coping response task conditions on stress pathology were investigated. In each of these conditions, the matched triplets design was employed. Each triplet was consisted of an experimental animal which could avoid or escape shocks, a yoked animal which received the same current intensity and duration of shocks as the experimental subject but which could not avoid or escape shocks, and a control animal which never was shocked during the experiment. In FR 1 or FR 2, the experimental animal was able to avoid or escape the shock by pushing a flapper once or twice, respectively. In FR 5 or FR 8, the experimental animal was able to avoid or escape shocks by producing five or eight flapper pushing responses, respectively. The effects of these different treatment conditions were evaluated by the development of gastrointestinal lesions and the amount of body weight loss during the experiment.
METHOD

Subject

One-hundred and eight male naive albino rats of the Wister strain at around 120 days old were used. Twenty-seven rats were assigned to each of the 4 FR value conditions. The body weight of the subjects ranged from 221 to 367 g at the beginning of the experiment.

Apparatus

The apparatus consisted of individual Plexiglas rat holders (Tohsoku and Company, Ltd.). The inside dimensions were 20.0 cm high, 9.0 cm wide and 19.5 cm long. The floor was constructed by stainless rods 0.35 cm in diameter and spaced 0.40 cm apart (described in detail by Hirai, Yamanaka, & Tsuda, 1974). The flapper or the nose key (4.0 × 9.0 cm) at the front of the rat holders, when pushed by the animal, activated a switch which was connected to a device which allowed the animal to escape from, or avoid of, electric shock delivered to the tail. The tail of an animal in the apparatus extended behind the rear of the rat holder and was held in this position by taping a small pieces of rubber tubing to the tail which prevented the animal from pulling its tail through a hole in the circular guard that rested against the rear of the rat holder. The shock electrodes, that were affixed to the extended portion of the tail, consisted of two 1.3 × 3.0 cm of copper clips. The shock source was a constant-current shockers (Tohsoku and Company, Ltd.) in series with the subjects. The sequence of the stimulus presentation was controlled by an automatic pattern generator (Dept. of Engineering, Sophia Univ.). Fixed-ratio (FR) schedule was maintained by a preset counter (Dept. of Engineering, Sophia Univ.) in series with the pattern generator. Each of the three rat holders was enclosed in a semi-sound proof box (45 × 68 × 43 cm). A 2-W white bulb was located in the ceiling of the enclosure. This bulb was turned on whenever the animal made the predetermined number of response (i.e., feedback stimulus). The semi-sound proof box was illuminated by a 2-W red bulb installed on the front wall of the enclosure throughout the stress session. The number of flapper pushing by all groups and shock pulses received by shocked groups during the experiment was continuously recorded with digital counters (LINE, type SMR DC 12V).

Procedure

Matched triplets of rats were used. Subjects were initially housed in group cages. Each triplet of rats matched for body weight was drawn from a group colony cage and placed in another cage where they had access to water but no food. Twenty-four hours later, each subject was placed in one of the rat holders and shock electrodes were attached.

Just prior to the first trial of the stress session they were randomly assigned to three different groups, one being designated as the experimental, which controlled the frequency and duration of shock by its response, another as the yoked, which received exactly the same number of shocks as the experimental subject but had no control over shocks and the third as the non-shock control subject. The tail electrodes of the yoked subject were, throughout the entire experiment, wired in series with those of the experimental subject so that the yoked animal received all shocks which were received by the experimental animal. The electrodes of the non-shock control subject were bypassed in the circuit so that this subject was never shocked.

Flapper-pushing response conditions

Each triplet was also assigned randomly to one of the four flapper-pushing response treatment conditions (FR 1, 2, 5, and 8). In FR 1, the experimental subject could control shocks by one flapper-pushing response within a 24 hr stress session. In FR 2, the experimental animal could control shocks by one flapper-pushing for the first 3 hr, but from that time the coping task was changed so that a double response was required to obtain the same effect. In FR 5, the coping task was effective with a response for the first 3 hr of the stress session, but the cumulation of five
time responses was required to avoid and/or escape electric shock after the 3rd hr. In FR 8, still the first 3 hr coping task was designed as FR 1 procedure, but for the remainder of the session the emission of eight responses was necessary was coping task. Though there was no warning signal followed by electric shock, a feedback stimulus was introduced into the unsignaled-shock condition. This stimulus was a brief (0.2 sec) light that followed each effective avoidance-escape response. For example, this feedback stimulus was presented whenever the experimental animal responded in FR 1, also in FR 8 this stimulus was administered for the eighth effective response. The yoked and the control animals also received the light stimulus whenever the experimental animal produced it.

The effect of the flapper-pushing response condition upon stress pathology was studied under a free-operant avoidance schedule. The contingency of response and shock was consistently the same through four FR conditions. Whenever experimental animal pushed the flapper at the front of its rat holder according to the number required, the next shock was postponed for 200 sec. Thus, if the experimental animal responded with the predetermined number during the shock, the shock was terminated and did not occur again for 200 sec. If the experimental animal responded with the regulative number prior to shock, the next shock was simply postponed by 200 sec. A total of 36 triplets (9 in each condition) was used.

**Stress session procedure**

**Training of flapper pushing (for 15 min).** At the beginning of the stress session the experimental animal received a brief period of training (15 min) of flapper-pushing. The shock, which was administered in pulses (pulse duration, 0.2 sec; interpulse interval, 0.4 sec), was kept at a low intensity during this phase (not exceeding 1.0 ma). On the initial trials the shock was reduced or terminated whenever the experimental animal moved toward the flapper and increased slightly when the animal moved away from the flapper. Intertrial interval was 60 sec during this training phase. Each response by the experimental subject produced a light (white bulb in 2-W) 0.2 sec in duration. This stimulus had two effects, one being a feedback of the shock termination to the shocked groups, another effect being aimed at promoting acquisition of avoidance by the experimental animal. It should be noted that yoked animals received all shocks and light signals that were received by experimental animals during all phases of the experiment including the training.

**Stress session (for 24 hr).** At the conclusion of training in flapper-pushing, the stress session was initiated. The Sidman procedure involved the use of a train of shocks whose S-S interval was 0.4 sec (pulse duration, 0.2 sec) in the absence of a flapper response and a 200 sec interval between response and shocks. In all four FR conditions, the animals were exposed to FR 1 which was lasted for the first 3 hr. From the 4th-hr one time flapper response could still terminate shocks under FR 1. On the other hand, only an accumulation of each predetermined number of response could postpone or terminate shocks under FR 2, 5 or 8. The shock, was initially set at an intensity of 1.5 ma and increased gradually until a maximum of 3.0 ma was reached. The stress session lasted for 24 hr. They were deprived of water and food throughout the session. The temperature of experimental chambers was about 22°C throughout the session.

**Method for the assessment of gastric lesions**

At the conclusion of the stress session, subjects were removed from each holder, weighted and sacrificed by decapitation. Immediately following sacrifice, subjects' stomachs were removed, opened by incision along the greater curvature, then pinned to cork-board and inspected macroscopically for lesions.

Two types of evaluation were made. A pathologist specialized in detecting and rating stomach pathology but who did not know which experimental conditions Ss had received, first counted the number of stomach lesions in each stomach individually. Lesions were identified as either a clearly visible defect or a bread in
the mucosa, which was often accompanied by hemorrhage. After completing this evaluation, he assessed the degree of abnormality. The principal criterion for abnormality was extent and severity of lesions using the assessment scale of Fuziwara and Mori (1970). A "0" indicated no change, "1" for small hemorrhagic points and edemas and "8" for many (greater than 2 mm in diameter) mucosal defects. Color photographs were taken for making an independent assessment by another pathologist at a later date.

To validate the presence of lesions, various stomach sections were immediately fixed in 10% buffered formalin, imbedded in paraffin and subsequently sectioned and stained with hematoxylin and eosin and later examined microscopically.

Statistical analysis

Non-parametric Mann-Whitney U-tests were employed for statistical analyses of the number of flapper-push responses by all groups and shocks received by shocked groups during the stress session. These tests were selected since the scores on these measures were not normally distributed. For comparisons between experimental, yoked and control subjects of the same FR conditions, sign tests for matched subjects were used. For comparisons between groups that were not of the same FR conditions, Mann-Whitney U-tests were used. For analyses on amount of shocks received by each FR group the H-test was used. On the other hand, gastrointestinal lesions and body weight measures were performed by a parametric analysis of variance. If the effects were significant by the analysis of variance, subsequent t-tests were used.

RESULTS

Stomach lesions

Gastric lesions were found in the lower glandular portion of the stomach. No lesions were found in the upper, rumenal area of the stomach. Such a typical lesion as it appeared in the stomach of one yoked subject in the FR 2 condition, together with normal stomachs of experimental and control subjects are pictured in Fig. 1. A histological section of this lesion also is illustrated in Fig. 2. This section shows an area of glandular gastric tissue, presenting a localized area of superficial alternations of the mucosa. These foci are characterized by loss of cellular outlines and shrinkage of the glandular cells, generalized cosinophilia of the cell remnants with loss of typical differential cytoplasmic staining, nuclear shrinkage, pyknosis, karyorrhexis, and a general stippling with brown pigment granules. This pigmentation is interpreted as the result of the action of the gastric section on foci of hemorrhage into the mucosa. Extension of the erosions into the muscularis mucosae, however, is not present.

Fig. 3 shows the mean number of lesioned gastric tissue found in each group of these FR treatment conditions. The number and score of lesions were analyzed by

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Fig. 1. (A) · (B): Appearance of normal rats' stomaches (each experimental and control subject in FR 2) and (C): a stomach containing gastric erosions (one yoked subject in FR 2).
a 4(FR conditions) × 3(groups) factorial analysis of variance. In the case of the number of lesions data, the main effects for both conditions ($F=4.15$, $df=3/96$, $p<0.01$) and groups ($F=24.41$, $df=2/96$, $p<0.01$) were significant. The FR conditions × groups interaction ($F=3.56$, $df=6/96$, $p<0.01$) also was significant. Similarly, the score of lesions data revealed significant levels of 1% for three factors (conditions: $F=9.4$, $df=3/96$, $p<0.01$; groups: $F=49.6$, $df=2/96$, $p<0.01$; conditions × groups: $F=6.2$, $df=6/96$, $p<0.01$; respectively).

In FR 1, the experimental animals showed less extensive gastric lesions than the yoked animals. This difference was statistically significant ($t=2.24$, $df=16$, $p<0.05$). Gastrointestinal lesions of the experimental animals did not differ markedly from non-shock control animals which were consistently semi-restrained in the rat holder ($t=0.50$, $df=16$, $p>0.05$). The FR 2 produced a similar result as the FR 1, the yoked animals which could not terminate the shock by his response developed the largest amount of lesions in the three groups. However, in FR 5, this tendency reversed, i.e., the experimental group which could terminate the shock by his fifth response showed more lesions than the yoked. The experimental group developed significantly more lesions than the control animals ($t=6.44$, $df=16$, $p<0.001$). Also yoked animals showed significantly more gastric pathology than the control animals ($t=3.24$, $df=16$, $p<0.01$). Under FR 8, which could control the electric shock by eighth flapper-pushing response, the control animals developed a smaller amount of lesions than the experimental ($t=4.93$, $df=16$, $p<0.01$).
and yoked animals. Experimental animals showed more gastric lesion than the yoked animals, as was seen in FR 5.

An overall examination of the differences between FR conditions showed that experimental animals developed more gastric pathology in FR 5 than they did in either FR 1 \((t=3.07, df=16, p<0.01)\) or FR 2 \((t=2.58, df=16, p<0.05)\), in which experimental subjects produced a smaller amount of lesions. Also, experimental animals developed more lesions in FR 8 than they did in either FR 1 \((t=3.38, df=16, p<0.01)\) or FR 2 \((t=3.30, df=16, p<0.01)\).

**Body weight change**

Fig. 4 shows body weight loss during the stress session for all groups. The differences in body weight loss among the three groups within each treatment condition were analyzed using the analysis of variance. Condition difference \((F=8.16, df=3/96, p<0.01)\), group difference \((F=119.39, df=2/96, p<0.01)\), and groups x conditions interaction factor \((F=32.42, df=6/96, p<0.01)\) were all significant. It was obvious that the major differences existed between the non-shock control in FR 8 compared to the experimental group \((t=3.12, df=16, p<0.01)\) and the yoked group \((t=2.29, df=16, p<0.05)\). The experimental group produced less body weight loss in FR 1 or FR 2, and produced more loss in FR 5 and FR 8 than yoked animals, though differences between these groups failed to reveal any significance for all four FR conditions. The difference of experimental animals between FR 1 and FR 8 was significant \((t=2.20, df=16, p<0.05)\).

The prestress weight, which was recorded prior to the placement of the animals into the rat holder for the stress procedure, was similar for all groups.

**Flapper-pushing behavior (Avoidance-escape response) and Number of shock pulses**

Fig. 5 shows the median number of 3 hr blocks of flapper-pushing responses for all groups and the median number of 3 hr blocks of shock pulses received by shocked groups (experimental and yoked groups) in each condition. As expected, experimental animals made significantly more responses than yoked animals in each FR condition except the FR 1 condition \((\text{sign test, } p<0.02 \text{ in FR 2}; p<0.05 \text{ in FR 5}; p<0.05 \text{ in FR 8, respectively})\). Similarly, experimental animals made significantly \((\text{at least } p<0.05)\) more responses than control animals in each FR condition. The response of yoked subjects during stress was only slightly greater than that of non-shock control subjects in each condition, and the differences between these groups were not significant. For the experimental group, significant comparisons using U-tests revealed an increasing function across all FR treatments. That is, the number of flapper-pushing behavior of experimental subjects was ranked as follows: FR 1< FR 2<FR 5<FR 8. On the other hand, for yoked and control animals, there were no recognized differences among all FR conditions. Approximately 90% of the experimental group in each FR condition did not often respond during the R-S interval but responded quickly after the shock pulse began, thus terminating it, i.e., they primarily escaped from shock. It was possible that rats have trouble in learning to bar press to avoid shock, but
learn to escape (discussed by Bolles, 1972). Thus, this accounted for the high number of shock pulses received in these conditions.

Transition of response across time course showed that responses of the 6th hr (the second block) and the last 3 hr (the eighth block) decreased significantly from that of
the first 3 hr (the first block) in the experimental group with FR 1 ($p<0.05$). However, in FR 5 and FR 8, as time passes, the number of response of experimental animals increased although those of yoked and control animals decreased. The experimental animals under these FR conditions naturally made more responses than other groups.

Median number of 3 hr blocks of shock pulses received by experimental and yoked animals during the 24 hr stress period was plotted in Fig. 5. As the number of responses required to avoid shock began to increase, the amount of shocks increased also, but the difference between FR conditions was not significant ($H$-test, $H=3.00$, df=3, n.s.). The number of shock pulses had considerable variation among the matched pairs. This was due to results of the performance of the subject assigned to the experimental group. For example, in FR 1, the matched pair which received the least shocks among the nine pairs was 3575 pulses. In contrast, another pair received the highest of 19862 pulses.

The relation between the amount of shock and time course showed that the number of shock pulses of the second block, which was changed from the FR 1 condition to each FR condition, increased significantly over that of the first 3 hr in FR 2, 5 and 8 conditions ($p<0.05$ for all groups). Especially, in FR 8, the number of shocks of the second block was four times higher than that of the first block. However, except for the FR 8 condition, the amount of shock pulses decreased from the second block of session as time passes.

**Discussion**

The authors interpret these results as an evidence for the hypothesis that the amount of required instrumental control task to a subject is a major determinant of the psychologic severity of stress. The amount of effort required to perform the avoidance-escape response was not similar for all FR conditions; the FR 5 and FR 8 coping tasks are more effortful, difficult and/or expose the experimental rat to a greater stressor than the FR 1 and FR 2 tasks.

So, being able to perform an easy coping task decreased the stress but as the task became more difficult, the subject seemed to have fear not only of the stressor but also of the performance of the coping task itself. Therefore, in FR 1, in which the experimental animal could control the stressor by a single flapper-pushing response, the experimental animals which could perform a coping response to avoid and/or escape electric shock pulses developed less severe physiological symptoms of stress than yoked subjects which received the same number of shocks but could not perform such coping response. Also, when two responses were required as the coping task FR 2, the experimental group showed slightly more lesions, but their yoked partners showed far more stomach lesions. Whereas, with harder tasks (FR 5 or FR 8), experimental subjects developed more severe gastric lesions and body weight loss than did their yoked partners. In all FR conditions, control animals which developed a small amount of stomach lesions as a result of the 24 hr restraint in the rat holder without food and water, showed less pathology than did animals which received shocks (experimental and yoked groups). For the experimental group which had an instrumental means to control the stressor, it was greatly beneficial if the work was simple and easy but should be greatly aversive if the work was difficult. On the other hand, regardless of whether the task was simple or difficult, the yoked group maintained its emotional position (helplessness) across the various FR conditions. Helplessness or "giving up" in the operational terms of a laboratory experiment means that a yoked animal has no solutions available and
hence there is nothing it can do (see Maier & Testa, 1975; Seligman & Beagley, 1975).

The present study might explain the discrepancy between the results obtained by Brady, Porter, Conrad, and Mason (1958) and Weiss (1968, 1971a, b, c). FR 1 and FR 2 conditions were similar to procedure of Weiss's experiments on the nature of coping task, and FR 5 and FR 8 conditions were analogous as stress condition to Brady's experiments. In Brady's experiments, though an experimental (executive) monkey could avoid a shock by means of pressing a lever (as well as the FR 1 condition in this study), he could postpone the occurrence of shock for only 20 sec. Therefore, because the response could produce only a shorter safety period (interstimulus interval, ISI), the executive monkey had to emit many responses to avoid or escape shocks. So the executive monkey had to remain alert continuously and act appropriately in order to avoid the shock, and surprisingly this monkey made 15-20 responses per minute (Brady et al, 1958). It was quite possible that a seemingly easy coping task employing their experiment was actually a stressful one because the executive monkey had to produce numerous responses. Thus, the stress condition of Brady's experiments essentially became similar to FR 5 and FR 8, and the animal which had a coping response produced more severe gastric pathology than did the yoked animal, as well as results of FR 5 and FR 8 in the present study. Whereas, the case of Weiss's experiment, avoidance-escape animal's response at least had the safety period of 200 sec. Since only a single coping response could produce a longer ISI period, the animal needed to produce only a few responses. So the stress situation of Weiss's experiment was a simple and easy coping task condition like that of FR 1 and FR 2 conditions in this study. Therefore, the rats which were able to avoid or escape shock were found to show considerably less gastric lesion than did their yoked helpless partners. As a matter of fact, some findings from our laboratory had suggested that the physiological symptoms of stress was changed by the length of safety period (ISI) produced by each coping response. Tsuda and Yamanaka (1974) and Tsuda, Hirai, and Yamanaka (1974) observed that by alternating the R-S interval, which might control the rate of the experimental animal's response, experimental subjects which could perform a coping response developed less stomach ulcerations than did yoked subjects in the case of R-S 220 sec, while experimental animals showed severe gastrointestinal lesions and body weight decrement than did yoked partners in the case of R-S 25 sec interval.

Lindsay and Norman (1972) have stated that the executive monkey differed from his partners in that he had to make the decisions. Having control seemed to be the critical factors in stress. It was not simply contact with a painful event. Stress was only produced when the organism had to develop some way of coping with a threatening situation. Likewise, Miller and Weiss (1969) have suggested the difficulty of the coping task influenced on the effects of reducing or increasing the stress produced. Accordingly, results of FR 1 or FR 2 were placed at the extreme of the easy and simple end of the dimension on the continuum for the nature and/or difficulty of the coping task. Typical results of FR 5 or FR 8 were put at other end of the extreme of the difficulty of the dimension on the continuum for the nature and/or difficulty of the coping task. Therefore, it was possible to place the results obtained by Brady et al. and by Weiss which appeared to be discrepant on the same continuum.

The second purpose of the present experiment was to evaluate the fitness of Weiss's prective ulcer model to the present study which used overt behavioral indexes—the median number of 3 hr
blocks of flapper-push responses, and shocks and amount of feedback stimuli received by all groups during the stress session. According to Weiss's theory, two variables, responding and relevant feedback, are related to ulceration. Ulceration will increase as the number of responses increases, and ulceration will decrease as the amount of relevant feedback from responses increases (Weiss, 1972a, b). The present results were compatible with his predictive ulceration model. The control rats that received no shocks in all four FRs developed less ulceration, since the number of responses emitted by these rats was very low (469 responses/condition). The yoked group showed a constant level of stress pathology, such as 3.00 gastric lesions per condition, as well as about 8.5% body weight loss per condition. This seemed to correspond with the fact that this group made the same responses (1248 responses/condition) across all four conditions. The number of attempts emitted in each condition was the same, thus, almost the same degree of lesions was observed across all FR conditions. Actually, the responding feature of the yoked rat in four FR conditions was probably clawing at the flapper in an attempt simply to get out of the rat holder. It was found that there was a progressive increase in gastric lesion in the experimental group as the number of avoidance-escape responses increases. Thus, gastric lesions of experimental animals were an incremental function of FR schedules. This increased stress pathology might be elicited because the increment of response required to avoid or escape shocks. With a minimum amount of work load, the experimental animals could control electric shocks to avoid or escape pushing a flapper once or twice. With harder tasks, however, they were able to avoid or escape shocks by producing many responses. So, the mean number of flapper pushing responses per block, in fact, was 61 in FR 1, 285 in FR 5, 392 in FR 8 conditions, respectively, and the mean number of gastric lesions was 1.22 in FR 1, 3.66 in FR 5, 4.00 in FR 8, respectively. The results of the present study clearly supported Weiss's proposition that ulceration increased as the number of responses increases.

In experimental animals, the number of shock tended to increase as the number of responses required to avoid or escape shock increases, but this tendency was not statistically significant. And the yoked group which received exactly the same number of shock showed no difference of stomach ulceration within all FRs. Therefore, this finding of progressive increase in ulceration in the experimental group with an increasing rate of FR schedule, did not arise from the amount of shock received, but was due to the difference among the amount of physical tasks or the difficulties of the coping task, i.e. values of FR schedules. Such findings, however, must not be interpreted to imply that psychological variables are always of profound significance moreover the occurrence of shock per se but the role of such variables turn up greater than might have been expected.

The concept of feedback also appeared to have an important role in the present study. According to Weiss's theory, feedback was defined as stimuli produced by the responses of an organism. The amount of relevant feedback meant the extent to which a response-produced stimulus was not associated with the stressor. For example, in the present experiment if experimental animals turned off the shock pulse delivered through his tail by pushing the flapper with his nose or front feet, this animal would produce a positive relevant feedback. A brief light stimulus was presented whenever the effective response was made. Thus, this signal constituted an external stimulus event that was not associated with the stressor. For example, in the present experiment if experimental animals turned off the shock pulse delivered through his tail by pushing the flapper with his nose or front feet, this animal would produce a positive relevant feedback. A brief light stimulus was presented whenever the effective response was made. Thus, this signal constituted an external stimulus event that was not associated with the shock, and made a remarkable high feedback, also. Whereas, any attempts yoked animals made to get out of stress produced zero relevant feedback be-
cause no response ever produced escape from electric shock. In other words, regardless of what they did they got no feedback which works. Such response was not reinforced for yoked animals under each FR condition, which remained in a problem-solving situation. For example, the yoked group with FR 5 initially made many responses, because this group might have tried to change the aversive circumstances by some random attempts. But the number of responses in this group began to decrease as time passes. From the data of these measurements it was natural to assume that yoked animals became passive in the face of trauma and might not respond at all, because this behavior etiology was adaptive in preventing the animal from wasting too much energy by struggling with a helpless situation. The above findings observed in the present experiment have been noted by Miller and Weiss (1969) as well as Seligman (1975a, 1975b). Having their control in a stressful situation, experimental animals did receive relevant feedback including external light stimulus which was not associated with electric shock whenever they responded under FR 1. Under FR 5 or FR 8, however, after the fifth or the eighth flapper-pushing response was emitted, the shocks were turned off and produced stimuli that differed from stressor was produced. So the amount of relevant feedback for a single response in FR 5 or FR 8 was as low as one fifth or one eighth compared to FR 1. Except for the fifth or eighth response, all other responses made by an experimental animal produced zero or negative relevant feedback because no response ever produced escape from the shock. Gastric pathology increase and the amount of relevant feedback decreases as the rate of FR schedule increases. The yoked rats for the FR 5 or FR 8 treatments had demonstrated the same incidence of stomach lesions as FR 1 or FR 2, and the experimental animals for FR 5 or FR 8 differed in the number of lesions from the experimental animals in the FR 1 or FR 2 schedules. These findings suggested that FR schedule which provided for the amount of relevant feedback for experimental animal's responding might be related to somatic stress reactions. That is, for yoked subjects, the FR schedule had no effect on the feedback consequences from responding, i.e., responses by the yoked animal continued to have no effect on the rate of FR, so that the relevant feedback from response remained at zero for these animals. But for the experimental animal, the additional rate of FR altered the response-feedback relationship. In a commonly used Sidman-type condition (FR 1), responses produced stimuli that were not associated with shock, whereas FR 5 or FR 8 a single response produced stimuli that were associated with the stressor except for the fifth or eighth responses so that the amount of relevant feedback was now very low or largely negative. Barbaree and Harding (1973) recently found that a high response rate providing no response-dependent feedback is the behavior which induced gastrointestinal lesions.

In the present results, with larger values of FR, psychological load increases, which in turn might result in more stomach pathology. However, the physical fatigue of the experimental animals associated with psychological load might produce more lesions.

**SUMMARY**

The effects of the coping response on stress pathology, such as gastric lesions and body weight loss by changing the values of fixed-ratio (FR) schedule for the coping response task in free-operant avoidance situation over 24 hrs were studied.

In FR 1 or FR 2 treatment conditions, experimental animals which could control electric shock to avoid or escape by pushing a flapper only once or twice developed less severe gastric lesions and greater body...
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weight loss than yoked animals which received the same amount of shocks but could not perform any coping responses. On the other hand, in FR 5 or 8, the experimental subjects which could control the electric shock by pushing five or eight times developed more severe gastric lesions and greater body weight loss than the yoked subjects, or control subjects which received no shock.

As experimental and yoked subjects received the same amount of shock through fixed tail-electrodes wire in series in each of the four FR condition, the difference between groups seemed to depend on some psychological factors. That is, in the case of a very easy coping task, capability of controlling aversive situation decreased the production of gastric lesions, but as the value of FR schedule became more increased, the experimental subject showed more severe stress pathology.

These effects show that the interaction between controllability of experimental environment and the amount of required coping response task plays an important role, which seems to support Weiss's ulcer-prediction model (1971a).

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