Somatic Effects of Predictable and Unpredictable Shock

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Four experiments examined the effects of stressor predictability on a variety of stress responses, such as stomach ulceration, plasma corticosterone concentration and body weight changes. Rats that received electric shocks unpredictably showed greater somatic stress reactions and more stress-induced pathology than animals that received the same shocks but could predict their occurrence by a signal. Subjects in the Unpredictable and Predictable shock conditions received shock simultaneously through fixed body electrodes wired in series, thus insuring that shock was always of exactly the same intensity and duration for the 2 groups. The results point up the importance of psychologic variables in affecting stress by showing that consequences of the same physical stressor can be markedly altered by psychologic factors such as predictability.

Psychologic factors influence stress reactions, including the development of stress-induced pathology. This is most convincingly demonstrated by administering exactly the same stressor (stress-inducing agent) to subjects that are in different psychologic conditions, so that the differences resulting from these conditions must then be due to psychologic variables. The present experiments utilized this design to study effects of stressor predictability: stress responses of animals that could predict when electric shocks would occur (because each shock was preceded by a signal) were compared with stress responses of animals that could not predict when the same shocks would occur (because the signal was presented randomly with no relation to the shocks).

Experiments which have studied the effects of signaled and unsignaled shocks have not reported consistent results. Three studies (1–3) measured changes in body weight in rats and mice and found that animals which received shocks preceded by a signal consumed less food and water and lost more body weight than animals which received unsignaled shocks. However, Seligman (4) observed in a bar-press experiment that animals which received signaled shocks developed fewer stomach ulcers than animals which received unsignaled shocks. Also, behavioral studies that have measured fear or anxiety by the Conditioned Emotional Response (CER) technic (4, 5) have reported that less anxiety re-

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sults from signaled than from unsignaled shock. In addition, Lockhard (6) found that animals will choose signaled rather than unsignaled shock. These findings could be reconciled by assuming that the same stressor condition has opposite effects on body weight gain from those it has on ulcer development and fear. However, in a series of studies, Weiss (7) used all these measures—weight loss, stomach ulceration and fear as measured by CER—and found that all measures showed the same effects.

The inconsistent effects of shock predictability may be due, in part, to a limitation of all the above studies except that by Myers (5). With the exception of the Myers experiment, they all used a grid floor to deliver the shock. With a grid, the animal can perform various responses, such as rearing, to reduce discomfort of shock, or can even escape shock entirely by jumping off the grid. Thus, the groups not only differed in the predictable-unpredictable nature of shock but may also have received different amounts of shock and/or differentially performed coping responses mentioned above.

The present study examined effects of predictable vs unpredictable shock on a variety of somatic responses. To eliminate differences in shock received, the shock was delivered through fixed tail electrodes.

EXPERIMENT 1

The first experiment examined effects of shock predictability on the development of stomach ulcers.

Method

The apparatus, shown in Fig 1, consisted of three soundproof compartments (Fig 1B). Each compartment (Fig 1A) consisted of an inner chamber (a large thermos container) housed in a sound-insulated box. The rat was in the inner chamber, lightly restrained in a tube of hardware cloth that permitted the animal slight forward and backward movement but prevented it from turning around. Air circulation through the inner chamber was maintained by a vacuum exhaust, with vacuum pressure regulated at 4 cm of H_2O.

The shock delivery technic was a slight modification of that described by Weiss (8). The electrodes were two 0.5 in. lengths of stainless steel taped onto the tail of each animal. Prior to affixing the electrodes, electrode paste was rubbed on the site of electrode contact. Since the electrodes were fixed on their tails, no postural change the animals made could alter the current intensity or duration of shock received.

The subjects were male, albino, Sprague-Dawley rats* approximately 180 g in body weight at the time of the experiment. Prior to experimental treatment, animals were housed in group colony cages, maintained on ad libitum food and water, on a 12-hr light-dark cycle.

Twelve triplets, each consisting of 3 rats matched for body weight, were used. Each day, a matched triplet (3 animals weighing within 10 g of each other) was drawn from the colony, and the animals were housed in individual cages without food for 24 hr. At the end of this time, the animals were placed in the apparatus and the shock electrodes were attached. (Temperaure probes, shown in Fig 1A, were not present in this experiment.)

After 1 hr of habituation, the experimental session was begun. One subject was randomly selected as the nonshock control, and never received shock. The other 2 subjects received shock (3.5 ma, 2 sec duration) on a variable schedule with an average interval of 60 sec. The tail electrodes for the 2 shock subjects were wired in series, as shown in Fig 1B, so that the shock received by these subjects was of exactly the same current intensity and duration. One shock subject (Predictable shock group), having been chosen randomly by the flip of a coin, received a beeping 1000-cps tone signal that began 10 sec before each shock. The other shock subject (Unpredictable shock group) received the same signal, but for this subject the signal was programmed separately so that it occurred with no relation to the shock. Thus, each matched triplet consisted of 1 subject from each of the 3 groups: a nonshock control, and 2 shock subjects that received the same electric shock—signaled for 1, unsignaled for the other.

After 19 hr, the animals were removed from the apparatus and placed in individual cages without

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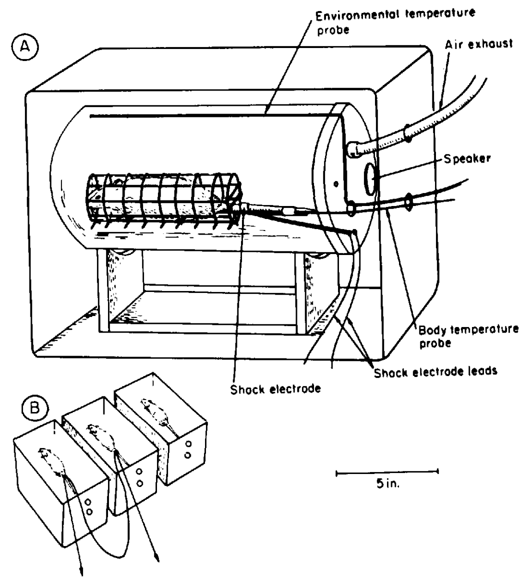

Fig 1. Apparatus used for presenting predictable and unpredictable shock. A shows details of chamber. B shows experimental situation, in which 3 matched subjects underwent experimental procedure simultaneously, 2 receiving same electric shock through fixed tail electrodes wired in series.

food. Six hours later, they were sacrificed by decapitation. Stomachs were removed, and lesions were counted and measured (7). During ulcer evaluation, the group to which each subject had belonged was not known to the person determining the ulceration.

All statistical comparisons, unless otherwise noted, were made by dependent *t* tests, using differences between matched subjects.

Results

Gastric lesions, or *stress ulcers*, were found in the glandular area of the stomach, their presence confirmed by histologic examination. Lesions in the upper, or ruminal, area of the stomach were found in 1 subject in the Unpredictable shock group.

Analysis of gastric lesions, shown in Table 1, indicated that animals which received unpredictable shock developed considerably more pathology than animals which received either the same shock preceded by a signal or no shock. As expected, Predictable shock animals showed more pathology than Nonshock animals, though even these developed some ulceration after 19 hr of restraint.

Table 1. Gastrointestinal Lesions

Group	Percentage showing lesions	Mean no. of lesions	Mean total length of lesions (mm)
Unpredictable shock (UPS)	100	6.6	8.9
Predictable shock (PS)	67	1.2	1.5
Nonshock (NS)	25	0.4	0.5
PS-UPS	$p < 0.10$	$p < 0.001$	$p < 0.01$
NS-UPS	$p < 0.001$	$p < 0.001$	$p < 0.01$
NS-PS	$p < 0.10$	$p < 0.10$	$p < 0.05$

The stomachs of each triplet were also compared. The judge, who did not know the group designation of the animals, ranked each triplet for extent of ulceration. The results, shown in Table 2, revealed that in every case the Unpredictable group showed the most ulceration. The Unpredictable group differed from both the Predictable group ($p < 0.001$) and the Nonshock group ($p < 0.001$), while the difference between the Predictable and Nonshock groups was not significant (Chi Square tests). Figure 2 illustrates 1 triplet of several which showed a large difference between the Predictable and the Unpredictable animals.

EXPERIMENT 2

The second experiment examined two other somatic responses to predictable and unpredictable shock. The first was change in body temperature, a response which occurs much more rapidly than stomach ulceration and which can be measured repeatedly across time in the same subject. The second was a hormonal response, concentration of plasma corticosterone, which was measured at the conclusion of the stress session.

Method

Subjects were of the same description as those used in Experiment 1. They were similarly divided into triplets and placed into the same apparatus as was used in the previous experiment. The 24-hr prestress deprivation was, however, omitted, subjects being drawn directly from the colony cages.

The stress procedure was also the same as in Experiment 1, except that different responses were measured. Body temperature of all animals was recorded at 1-hr intervals for the first 5 hr of the stress session. Temperature measurement was made by telethermometer from a rectal probe inserted 7 cm into the body cavity. At the conclusion of the stress session, animals were sacrificed by decapitation and blood was collected for determination of corticosterone content. Steroid assay was performed by the method of Guillemin et al (9). Ten triplets were sacrificed 5 hr after the stress session was begun; another 10 triplets were sacrificed 24 hr

Table 2. Frequency of Stomach Ulceration Rankings

Ulceration rank	Group: Unpredictable shock	Predictable chock	Nonshock
1 (least)	0	4	8
2	0	8	4
3 (most)	12	0	0

Fig 2. Glandular area of stomach from each of 3 subjects of 1 matched triplet.

after it had begun. The experimental procedure commenced at 2 PM each day, so that the 5-hr and the 24-hr sacrifice occurred at 7 PM and 2 PM, respectively.

Results

Changes in body temperature are shown in Fig 3. A greater rise was seen in the Unpredictable group than in the Predictable group. At the end of the first hour, the difference only approached significance ($p < 0.08$), but it became larger during the second hour, as the temperature of the Predictable group declined while that of the Unpredictable group continued to rise. By the end of the second hour, the difference was significant ($p < 0.01$) and remained so at the end of the third, fourth and fifth hours. The groups did not differ at the end of 24 hr.

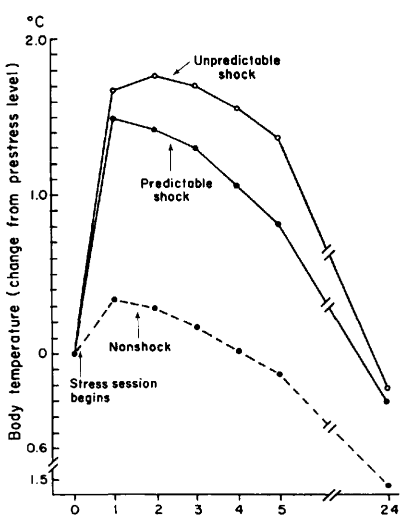

Fig 3. Mean change in body temperature for all groups during stress session. Initial mean temperatures, recorded just prior to beginning of stress session, for Unpredictable, Predictable and Nonshock groups were 38.21, 38.27 and 38.39 °C, respectively.

Concentration of plasma corticosterone is shown in Fig 4. As would be expected, the shock conditions raised plasma corticosterone levels. The Unpredictable group had higher levels than the Predictable group, both at 5 hr ($p < 0.05$) and 24 hr ($p < 0.03$). In comparison to Nonshock animals, both shocked groups showed significantly higher steroid levels at 5 hr. At 24 hr there was no apparent difference between the Nonshock and the Predictable group, and the difference between the Nonshock and the Unpredictable group approached but did not reach statistical significance ($p < 0.08$).

EXPERIMENT 3

The somatic responses measured in Experiments 1 and 2 all showed significantly larger changes when shock occurred unpredictably than when its occurrence could be predicted by a signal. Since previous studies which have not shown this effect have all examined changes in body weight, a third experiment in this series was car-

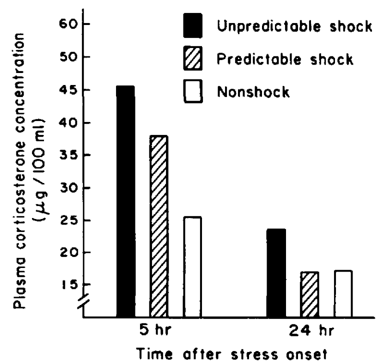

Fig 4. Mean plasma corticosterone concentration for all groups 5 hr and 24 hr after beginning of stress session.

ried out to determine the influence of predictable and unpredictable shock on body weight.

Method

The subjects, apparatus and procedure were the same as in Experiment 1, with the following exceptions. Prior to the stress session, all animals were housed in individual cages, where ad libitum food and water intake was measured daily. Subjects obtained food from a container with a trough attachment for collecting crumbs. Food containers and subjects were weighed on Ohaus triple beam balances, and water intake readings were taken from 50-ml graduated tubes that were refilled daily. A 12-hr light/12 hr dark schedule was maintained throughout the experiment.

The 3 subjects in each triplet were matched for body weight (within 10 g of each other) and also for rate of weight gain across a period of at least 1 week's duration (same criterion). The stress session was then conducted as in Experiment 1. Body temperature was recorded as in Experiment 2. The session lasted 5 hr, after which the animals were removed, weighed and returned to their home cages. Body weight, food and water measures were obtained every 24 hr thereafter. Seventeen triplets were used.

Results

Body weight change is shown in Fig 5. During the stress session, Unpredictable shock subjects lost significantly more body weight ($p < 0.03$) than Predictable shock subjects, and also more than Nonshock subjects ($p < 0.001$). The weight loss of Predictable subjects during stress was only slightly greater than that of Nonshock subjects, and the difference between these groups was not significant. During the first 24 hr following the stress session, both shocked groups lost additional weight; the Unpredictable group lost more weight in this period than did Predictable subjects, but this difference was not significant. At the end of 24 hr after the stress session, and at every 24-hr measure thereafter, the weight loss from prestress weight remained significantly greater for the Unpredictable

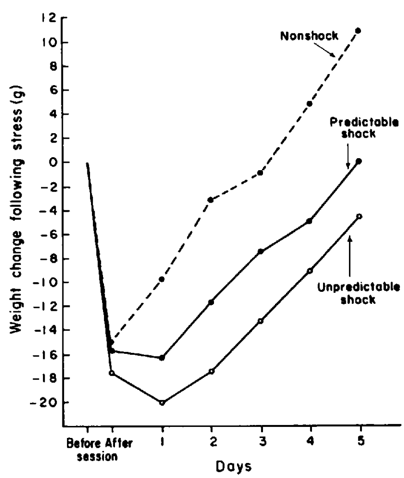

Fig 5. Mean change from prestress body weight for all groups. Measures were taken before and after 5-hr stress session, and at five 24-hr intervals thereafter. Mean prestress weights for Unpredictable, Predictable and Nonshock groups were 248.8, 248.3 and 250.0 g, respectively.

group (at least $p < 0.05$) than for the Predictable group. The Nonshock group, which gained considerable weight during the first 24 hr after stress, showed less weight loss at the end of this period ($p < 0.01$) than the Predictable group; the difference between these groups remained significant at all subsequent 24-hr measures. The difference between Nonshock and Unpredictable shock subjects was highly significant at all 24-hr measures (at least $p < 0.01$).

Food and water intake changes are shown in Table 3. For each animal, intake on the 3 days prior to the stress session was used as a baseline to take into account any individual differences. Results revealed that intake of Unpredictable subjects was more depressed than that of Predictable subjects after the stress session. The food

Table 3. Mean Change in Food and Water Intake Following Stress Session

Group	3-day baseline	24-hr periods following stress 1	2	3	4	5
		FOOD INTAKE (g)				
Unpredictable shock	20.9	−15.7	−4.8	−1.6	−1.3	−1.6
Predictable shock	20.7	−12.7	−3.2	−1.1	−0.6	−0.7
Nonshock	21.7	− 6.4	−1.0	−1.0	−0.5	0.7
UPS-PS		$p < 0.01$	$p < 0.10$	ns	ns	ns
UPS-NS		$p < 0.001$	$p < 0.001$	ns	ns	ns
PS-NS		$p < 0.01$	$p < 0.05$	ns	ns	ns
		WATER INTAKE (ml)				
Unpredictable shock	31.2	− 8.7	−2.9	1.2	−0.6	0.8
Predictable shock	31.8	− 8.5	0.1	0.0	0.9	−0.2
Nonshock	32.3	− 4.7	0.5	−0.2	0.3	−0.6
UPS-PS		ns	$p < 0.05$	ns	ns	ns
UPS-NS		$p < 0.05$	$p < 0.01$	ns	ns	ns
PS-NS		ns	ns	ns	ns	ns

intake difference between these groups was most notable in the first 24 hr after stress. A water intake difference was also evident but did not show up until the second 24-hr period, probably because stress can acutely increase water intake, which would tend to obscure early differences. Nonshock subjects ate and drank considerably more than Unpredictable subjects, but in comparison to Predictable subjects, differences were found in food intake only. Intake patterns had essentially returned to normal by the third poststress day.

Body temperature, also recorded in this experiment and shown in Fig 6, essentially replicated the results of Experiment 2, except that in this case Predictable and Unpredictable groups differed significantly at 3, 4 and 5 hr. Within the Unpredictable group, the amount of temperature rise recorded at the end of the fifth hour of stress correlated .69 with the amount of weight these subjects lost in the next 24 hr. This correlation, however, was only .33 in the Predictable group.

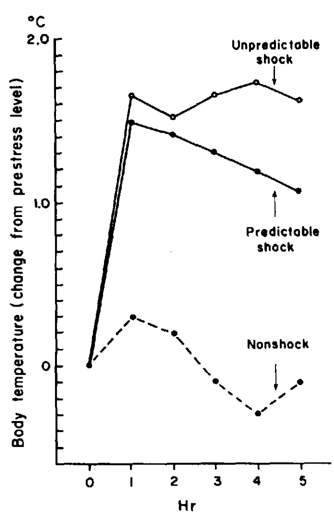

Fig 6. Mean change in body temperature for all groups during stress session in Experiment 3. Initial mean temperatures for Unpredictable, Predictable and Nonshock groups were 38.62, 38.57 and 39.00° C, respectively.

EXPERIMENT 4

Results of the previous experiment agreed with those of Experiments 1 and 2, and did not agree with earlier studies on body weight. One notable difference between the procedure of Experiment 3 and that of the earlier experiments on body weight is that animals were mildly restrained in Experiment 3 while they were free-moving in all previous studies. Experiment 4 therefore examined the effects of predictable and unpredictable shock on body weight in free-moving animals, but again used fixed tail electrodes. Also, two stress sessions were given in this experiment, as compared to one in Experiment 3.

Method

Subjects were of the same description as those in Experiment 1, except that heavier subjects were used (280 g when received). All animals were housed in group cages where ad libitum food and water were measured daily for at least 1 week prior to the initial stress session. The same light-dark conditions and measurement procedures were used as in the previous experiment, except that food was not kept in containers but was freely scattered on the cage floor. Food crumbs were collected below the cage and weighed in determining daily intake.

Triplets of animals matched for body weight as in Experiment 3 were selected. Each animal was weighed and placed in a Plexiglas box 8 in. × 8 in. × 8 in. which was enclosed in a Lehigh Valley sound-attenuated chamber. The animals were fitted with a tail electrode as described by Weiss (8), except that an additional layer of rubber, 1/8 in. thick, was placed on the outside of the electrode. The electrode was positioned approximately 1 in. down from the base of the tail, and the wires leading from the electrode were taped to the tail across this 1-in. space so that the wires did not protrude upward behind the rat but ran up the tail and onto the back. The wires were continued up the back to the rear of the neck, where an additional piece of tape anchored them, and from here they were connected to an overhead mercury commutator swivel. This arrangement did not restrict the animal's activity and was the most effective method tried for preventing the subject from biting the wires during the stress session.

As in previous experiments, 1 subject received signaled shock, another, unsignaled shock, and the third, no shock. A blinking light signal was used in this experiment. Shock and signal were delivered on the same schedule as in previous experiments; thus, the Predictable and Unpredictable shock subjects again received the same simultaneous shock through their tail electrodes, which were wired in series, with the Predictable subject receiving the signal beginning 10 sec before each shock and the Unpredictable subject receiving the signal with no relation to shock.

Two stress sessions were given, each 3 hr in duration, 48 hr apart. At the conclusion of each session, the electrodes were removed and the animals were weighed and returned to their home cages. Boluses defecated during the stress sessions were also weighed.

The electrode modifications described above did not completely surmount the problem of electrode- and wire-biting encountered when repetitive high-intensity, inescapable electric shocks are delivered for a total of 6 hr. If either the Predictable or the Unpredictable animal in a triplet disconnected its electrode at any time, the triplet was discarded. A milliammeter, placed in series into the shock circuit, indicated if any such disconnection took place, since in that event no current passed through either the meter or the animals. Twelve triplets were used in the experiment, of which 4 were discarded.

Results

Fig 7B shows body weight loss for each group during each of the two stress sessions, and weight change evident 24 hr after each of the two stress sessions. The Predictable and Unpredictable shock groups did not differ in weight lost during the initial stress session, but 24 hr after this session, the Unpredictable group had lost significantly more weight ($p < 0.05$) than the Predictable group. The Unpredictable group also lost more weight than the Predictable group during the second stress session ($p < 0.05$), though the difference at 24 hr in this case did not reach significance. The Nonshock group differed significantly from both shock groups in all instances. Changes in food and water intake following stress are shown in Table 4. Though

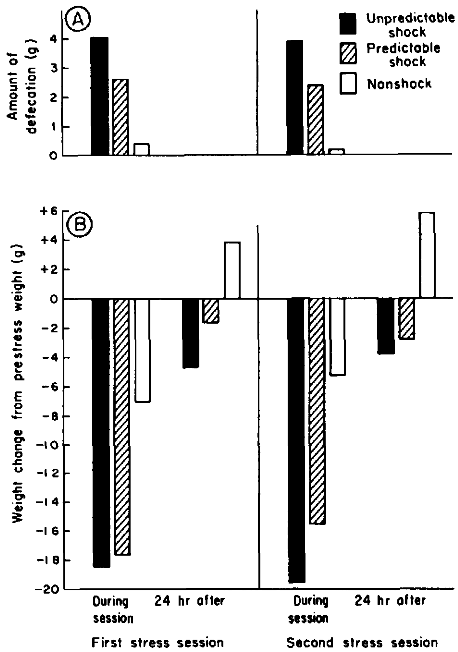

Fig 7. Mean amount of defecation during stress sessions (A), and mean change from prestress body weight during each stress session and 24 hr afterward (B) for all groups. Mean prestress weights for Unpredictable, Predictable and Nonshock groups were 335.9, 333.7 and 331.8 g, respectively.

the Predictable group ate and drank somewhat more than the Unpredictable group after both stress sessions, the differences were not significant.

The amount of feces defecated, a measure of fear in rats that was recorded during each stress session, is shown in Fig 7A. Total defecation during both stress sessions was greater ($p < 0.01$) in the Unpredictable group than in the Predictable group.

DISCUSSION

In the present experiments, stress reactions were more severe when the stressor occurred unpredictably than when its occurrence was predicted by a signal. Unpredictable electric shock resulted in more severe stomach ulceration, a greater rise in body temperature, higher plasma corticosterone concentration, more body weight loss, greater depression of food and water intake, and more defecation than did predictable shocks of the same intensity. Such results were obtained when the warning signal was either auditory (tone) or visual (blinking light), regardless of whether the animal was mildly restrained or free-moving. The tendency for an unpredictable stressor to produce more severe reactions than a predictable one would therefore seem to have considerable generality. The present results, moreover, are consistent with all known behavioral studies.

Table 4. Mean Change in Food and Water Intake Following Stress Sessions

Group	3-day base-line*	24-hr period following stress session: Session 1	Session 2
		FOOD INTAKE (g)	
Unpredictable shock	29.3	−9.1	−7.8
Predictable shock	28.2	−8.1	−7.8
Nonshock	28.7	0.4	1.2
UPS-PS		ns	ns
UPS-NS		$p < 0.001$	$p < 0.001$
PS-NS		$p < 0.001$	$p < 0.001$
		WATER INTAKE (ml)	
Unpredictable shock	42.7	−8.3	−7.9
Predictable shock	41.2	−7.4	−7.6
Nonshock	42.3	−3.7	2.6
UPS-PS		ns	ns
UPS-NS		$p < 0.10$	$p < 0.01$
PS-NS		ns	$p < 0.001$

* Intake baseline differs from that found in Experiment 3 because of differences in weight of subjects in the two experiments.

Discrepant Findings

However, the results of three studies (1–3), all of which measured body weight and food and water intake, do not agree with the present findings. These experiments found that signaled shock resulted in more weight loss than did unsignaled shock. Why did these studies consistently obtain apparently opposite results? Several possibilities can be suggested.

One might look to the measure used—body weight—as the key. Perhaps body weight in particular is severely affected when a stressor is predictable, whereas other measures are not. This explanation is not supported by the results of Experiments 3 and 4. However, body weight differences between Predictable and Unpredictable shock groups in the present study were not as great as, for example, differences in stomach ulceration, so that one might propose that this measure would be most susceptible to reversal under certain conditions. This may indeed be correct, but does not explain the present contradiction.

Some difference in the experimental conditions of the present study, in comparison to the conditions of the earlier experiments, seems more likely to have produced the discrepancy in results. A difference in chronicity of stress is one possibility. Each of the three earlier studies employed more chronic stress than the present one, using stress sessions lasting 20–24 hr/day for several days. But all of these studies showed that the differences occurred rather quickly, appearing most distinctly on the first day of stress, after which changes greatly diminished and often ceased within a few days. Insofar as the important differences occur quickly, one would not expect chronicity of the stress condition to explain the divergent findings.

Another possibility, which may be the most important, is that the electric shock was delivered through fixed body electrodes in the present experiments and through a grid floor in the others. On a grid floor an animal can alter shock by changing its bodily position; for example, it can reduce discomfort by receiving shock through its tough rear feet rather than through its more sensitive forepaws, or momentarily terminate shock entirely by jumping. Animals generally do attempt such responses when grid shock is given. In the earlier studies being discussed here, such coping attempts would necessarily be very inefficient since the shock, being of fixed duration, was essentially inescapable. Nevertheless, limited success could have been attained on some trials, so that such coping responses, inefficient though they were, may have persisted. We now have obtained results (10) showing that if coping responses are inefficient, stress reactions are quite severe, often more so than if no coping responses are attempted; if coping responses are intermittently punished, as would have occurred if a burst of shock were experienced after a coping attempt, reactions are aggravated still further. A signal before shock would ostensibly permit the animal to initiate, or prepare to initiate, the responses described above, and so animals receiving signaled shock may have performed more of these inefficient responses than animals having no signal. With the use of fixed electrodes, the situation is quite different. Because the shock is highly consistent in duration and intensity from trial to trial, the animal will quickly learn that *all* behavior is equally ineffective in altering shock, and such responses will cease. Thus, when shock is given through a grid floor, the predictable-unpredictable variable may be confounded by a variety of inefficient coping responses which increase stress reactions; with fixed electrodes this confounding does not occur.

What is Important: Predicting Shock or Safety?

Why did predictable shock reduce stomach ulcers, weight loss, etc, in comparison to unpredictable shock? Are stress responses reduced when a warning signal is given because the animal knows just when the stressor will occur? Or are they reduced because the animal can therefore determine when shock will not occur—ie, when it is safe? This latter hypothesis, presented by Seligman (4), states that the animal is less afraid (or less stressed) when shock is signaled because stimuli of the "no signal" period are associated with the absence of shock, and thus become a safety signal. All previous experiments, as well as the present studies, which have compared signaled and unsignaled shock in basically the same manner, do not permit one to choose between these two alternatives.

Answering this question is obviously important for understanding how predictability produces such remarkable effects. Because the two alternatives stated above are so closely related, the experimental design problems in separating them are considerable. One study carried out in another context in this laboratory may suggest one avenue of approach. Two groups of rats were exposed to intermittent electric shock for 48 hr. Both groups of animals received signaled shock (as did the Signaled shock groups in the present study) with a high-pitched beeping tone preceding shock by 20 sec. For 1 group, 3 min of silence intervened between each beep-shock trial. For the other group, however, the 3-min

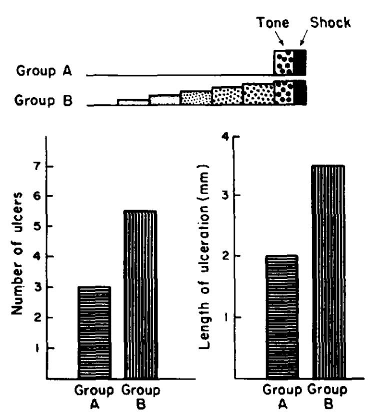

Fig 8. At top, presentation of shock and tones for 2 groups: Group A received a single tone before shock; Group B received a succession of tones. At end of 48 hr ulceration found for 2 groups is shown below. With 25 subjects in each group, total length of ulceration was greater ($p < 0.05$) in Group B than in Group A.

period was divided into six 30-sec periods, with silence occurring for the first 30 sec after which a series of five steady tones were introduced, each lasting 30 sec and each increasing in pitch and intensity with respect to the previous tone. The arrangement of stimuli is diagrammed in Fig 8. In the latter group, the steady tones will provide these animals with an *external clock* so that they will have better information than the animals in the first group as to just when the stressor will occur. On the other hand, the former group will have more of that safety condition (silence) which occurs when the shock terminates. Stomach ulceration found in both groups is also shown in Fig 8. The suggestion of these results, which awaits more detailed analysis, is that safety is the more important factor in reducing stress.

The Role of Psychologic Factors in Stress Reactions

It has long been acknowledged that psychologic factors may influence stress reactions (11); this was clearly confirmed in the present study by the demonstration that the same physical stressor produced different effects, depending on whether its occurrence was or was not predictable. The present results showed, moreover, that for certain responses, such as stomach ulceration, psychologic variables apparently can be even more important than the systemic stressor. In Experiment 1, animals that received signaled shock were more similar in amount of ulceration to animals that received no shock, than they were to animals that received unsignaled shock; the latter group developed far more ulceration than either of the former groups. Weiss (7) reported a similarly large effect of another psychologic variable—the ability to avoid or escape shock—in another series of experiments where the same stressor was given to animals under different psychologic conditions. Such findings must not be construed to mean that psychologic factors are always of profound significance, but the role of such factors does appear greater than might have been expected, and their potential importance should not be underestimated.

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