Pavlovian Fear Conditioning and Learned Helplessness: Effects on Escape and Avoidance Behavior of (a) the CS–US Contingency and (b) the Independence of the US and Voluntary Responding[1]

Steven F. Maier[2]

Martin E. P. Seligman[3]

Richard L. Solomon[4]

UNIVERSITY OF PENNSYLVANIA

Two-process learning theories postulate two kinds of learning: the formation of Pavlovian CR's based on contiguity of CS and US, and the strengthening of instrumental responses resulting from reward and punishment. Beyond this, these theories postulate interrelationships between the Pavlovian conditioning process and instrumental behavior. One postulate is that Pavlovian CR's mediate or motivate instrumental behavior. For example, a CS+, paired with shock in a separate Pavlovian conditioning session, should excite fear. Presentation of this CS+ should energize any instrumental behavior which is motivated by fear. A CS−, previously paired with the absence of shock in a separate Pavlovian conditioning session, should inhibit fear and depress any fear-motivated response. We will discuss evidence which strongly confirms these postulates.

A procedural regularity characterizes almost all of the experiments which support mediation theory: the CS's are imposed on already established instrumental avoidance responses. First, a subject is trained to avoid. Only then is Pavlovian conditioning carried out. Conditioning can, of course, be carried out before avoidance training. However, we have found it very difficult to produce any escape or avoidance responding at all, if a dog first receives Pavlovian conditioning with shock. This fact led us to think about the voluntary skeletal responses the dog may make while he is being classically conditioned.
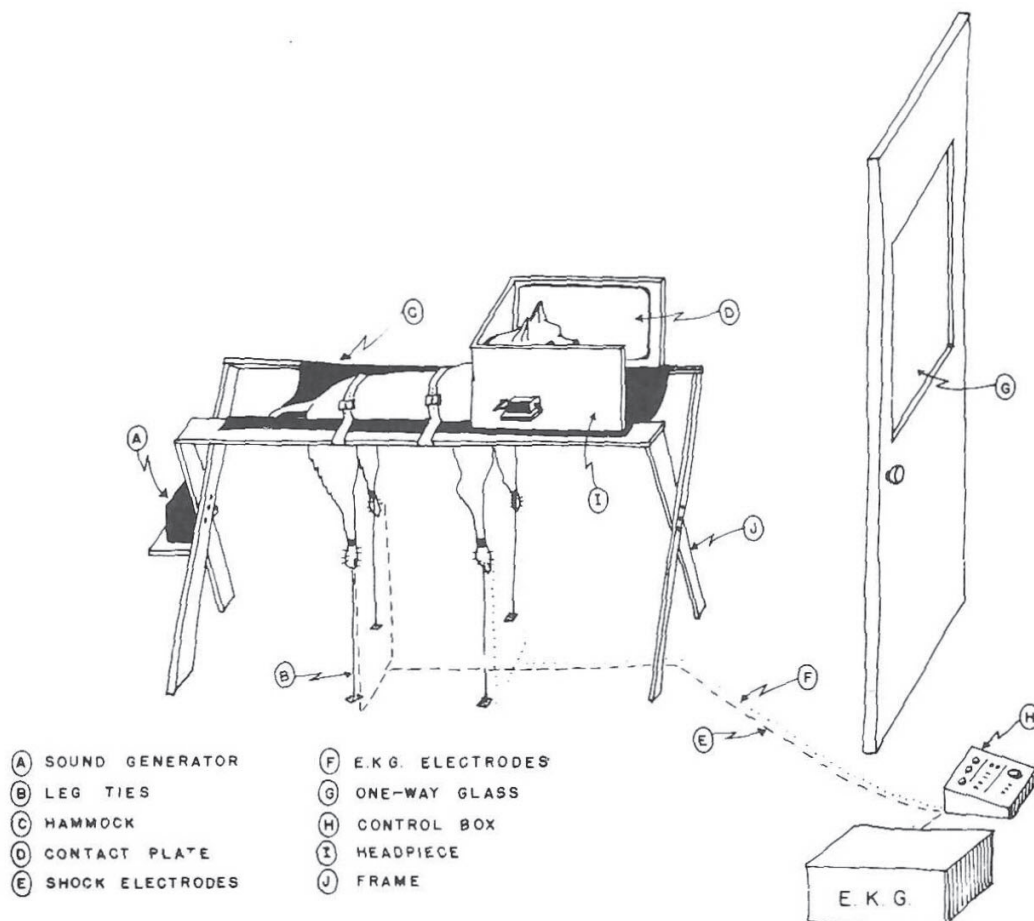

FIG. 10–1.   Pavlov harness used either for fear conditioning or for escape and avoidance training. The contact plate (D) is the manipulandum for instrumental training. Shock electrodes are attached to hind paws. CS's are presented by tone generator (A).

What skeletal responses does a dog make during conditioning? Consider a dog strapped into the harness shown in Fig. 10–1. He is given a sequence of tones paired with traumatic electric shocks delivered to his hind feet. Figure 10–2 schematizes some of the events that typically occur in such aversive conditioning. Among these events are voluntary skeletal

responses. The dog may turn his head, struggle, howl, stiffen, lift his paw, relax, wag his tail, pull in his gut, and so forth. However, the dog's responses do not affect the occurrences of the CS and US. Indeed, this independence between the subject's responses and the occurrence of CS and US distinguishes Pavlovian conditioning from instrumental training. But, surprisingly, nothing more has been made of it beyond using it to make that distinction.
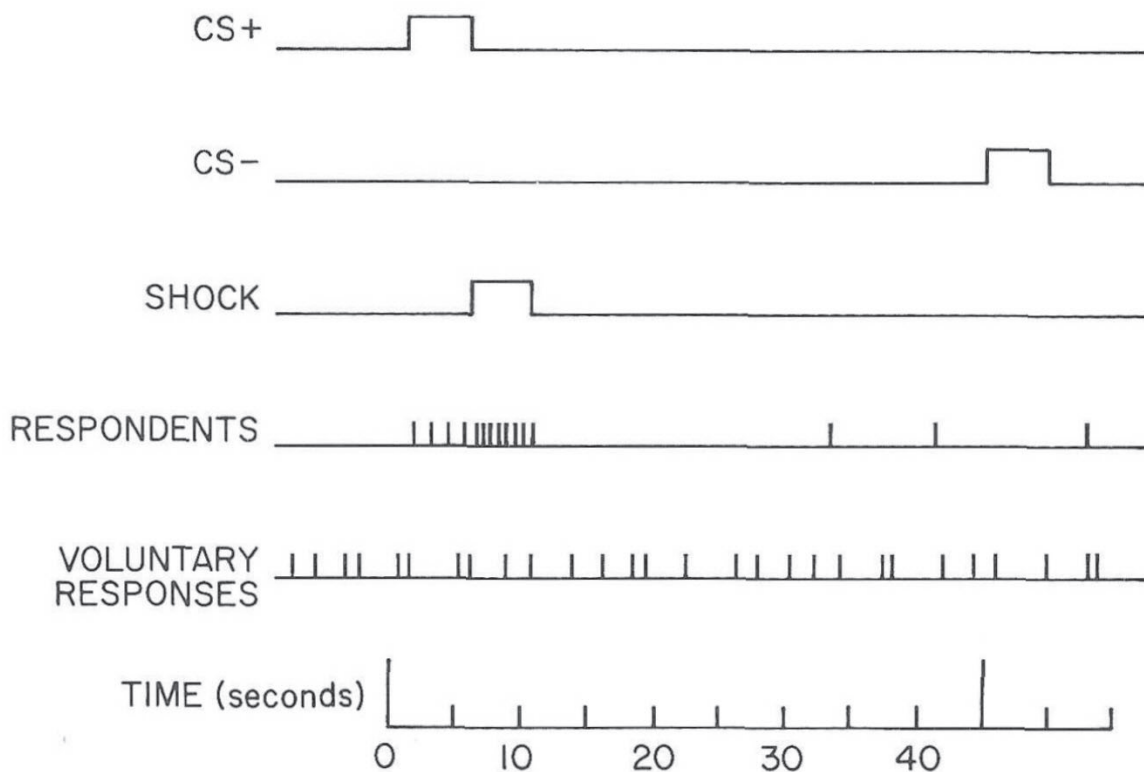

FIG. 10–2.   Diagrammatic representation of typical events during two Pavlovian fear conditioning trials. The CS+ lasts 5 seconds and overlaps with a 5-second shock. The CS−, a contracting, unreinforced CS, comes on after an intertrial interval of 45 seconds. The respondents elicited by CS+ are usually orienting or investigatory reflexes. Respondents elicited by shock are leg-flexion reflexes, vocalization, defecation, urination, piloerection, cardiac acceleration, gasping, etc. Voluntary responses elicited by shock are struggling movements of a wide variety.

It seems naive for us to have thought that the dog might simply ignore the fact that what he does during Pavlovian fear conditioning does not affect what happens to him. It would be a woefully unadaptive organism which was not sensitive to the fact that he is helpless. We shall argue that organisms learn about such independence between responding and reinforcement. We shall further argue that this learning produces profound interference with subsequent instrumental escape and avoidance learning.

In this chapter we discuss two sets of relations among the events of

Pavlovian fear conditioning. First, we describe the effects of the CS–US contingency on avoidance behavior. Later we describe the effects of the dog's helplessness during fear conditioning on his subsequent escape and avoidance learning.

Pavlovian Fear Conditioning: The CS–US Contingency in Aversive Pavlovian Conditioning Controls Already-Learned Escape and Avoidance

The concerted effort in our laboratory to study the effects of aversive Pavlovian conditioning on aversively motivated instrumental performance arose from our interest in the postulates of two-process learning theory. If, indeed, instrumental avoidance responses are mediated by a conditioned emotional reaction (CER) or a conditioned fear state, and if the conditioning of fear obeys the laws of Pavlovian salivary conditioning, then Pavlovian aversive conditioning procedures should predictably influence instrumental avoidance responding. All of the phenomena of Pavlovian salivary conditioning should be demonstrable in Pavlovian fear conditioning; and, in turn, these phenomena should reflect themselves in the control of avoidance responding by Pavlovian CS's. A detailed discussion of this theoretical position has recently been published by Rescorla and Solomon (1967).

The mediation postulate of two-process learning theory can take two forms. The strong form holds that a conditioned fear response *does* in fact mediate all avoidance responding; that is, the subject succeeds in avoiding shock because he learns to escape from the fear-eliciting CS. The weak form holds that a conditioned fear response *can* mediate avoidance behavior. The data we describe will substantiate the weak form of the fear-mediation postulate: fear-producing and fear-inhibiting CSs established by Pavlovian procedures *can* mediate avoidance responding. We have not established whether escape from fear is the mechanism that ordinarily mediates avoidance behavior. Thus, although we lean toward the view that escape from a fear-eliciting CS may mediate the acquisition of early avoidance responses, it is certainly possible that escape from the CS is not necessary for the maintenance of avoidance. At asymptotic avoidance performance (1) subjects often become quite nonchalant responders (Solomon, Kamin, & Wynne, 1953); (2) subjects may not show a CER to the CS (Kamin, Brimer, & Black, 1963); (3) subjects often do not show peripheral autonomic nervous system (ANS) arousal to the CS (Black, 1959); and (4) subjects often respond with an avoidance latency

that may be too short to allow significant ANS arousal (Solomon & Wynne, 1953). All these data suggest that the subjects may not be escaping from a fear-eliciting CS when avoidance behavior is well learned. They may be responding in order to avoid the US.

Testing the Fear-Mediation Concept

The difficulty of validating the fear-mediation concept is illustrated by some procedures used by Sidman et al. (1957). While their monkeys were lever pressing at a steady rate in order to avoid shock and were receiving very few shocks each session, the experimenters presented them with a sound which lasted 5 minutes. At the termination of the sound, a brief shock occurred. The monkey could do nothing to change this sound–shock contingency. After many pairings of sound and shock, the onset of the sound alone increased the lever-pressing rate.

Two-process theories of avoidance learning argue that the sound, by association with shock, aroused a conditioned-fear reaction similar to that motivating the lever-press response. Thus, the sound, a CS+, added to the fear-eliciting effect of the training situation, with the result that the total fear was greater in the presence of the CS+ than in its absence. Therefore, the lever-pressing rate increased in the presence of CS+.

There is, however, an alternative to this fear-mediation interpretation. It was put forth by Sidman et al. in explaining their findings. The new sound–shock pairings were imposed on subjects that were already lever pressing at a rapid rate. Shock termination sometimes occurred directly following a lever press in the presence of the sound. It was argued that such pairings should reinforce lever pressing in the presence of the sound. This type of adventitious or superstitious instrumental reinforcement is always a problem when subjects are conditioned "on the base line"; i.e., while they are exercising a free operant. Therefore, although the Sidman et al. procedure suggests that the rate of lever pressing may be a function of the momentary intensity of Pavlovian-conditioned fear, it leaves open the possibility that the lever pressing was actually strengthened via another mechanism, an instrumental reinforcement contingency stemming from shock termination.

Solomon and Turner (1962) attempted to prevent this confounding of Pavlovian and instrumental contingencies. They gave instrumental shock-avoidance training to dogs in the panel-pressing apparatus (see Fig. 10–1). After the dogs had learned to avoid shock by making short-latency responses to a visual S+, they were completely paralyzed by d-tubocurarine. Then they were subjected to Pavlovian discriminative-conditioning procedures in the same apparatus. A tone of one frequency (CS+) was consistently paired with shock, and a tone of another fre-

quency (CS−) was never paired with shock. Two days after recovery from curarization, the subjects were tested in the panel-pressing apparatus. They retained their short-latency avoidance responses to the visual S+. More importantly, when the CS+ was presented, the dogs responded with a short-latency panel press. When CS− was presented, the dogs either did not respond or responded hesitantly. The conditioning procedure thus resulted in immediate discriminative control of previously established instrumental responses by Pavlovian CS's that had not been present during avoidance learning (see Fig. 10–3).
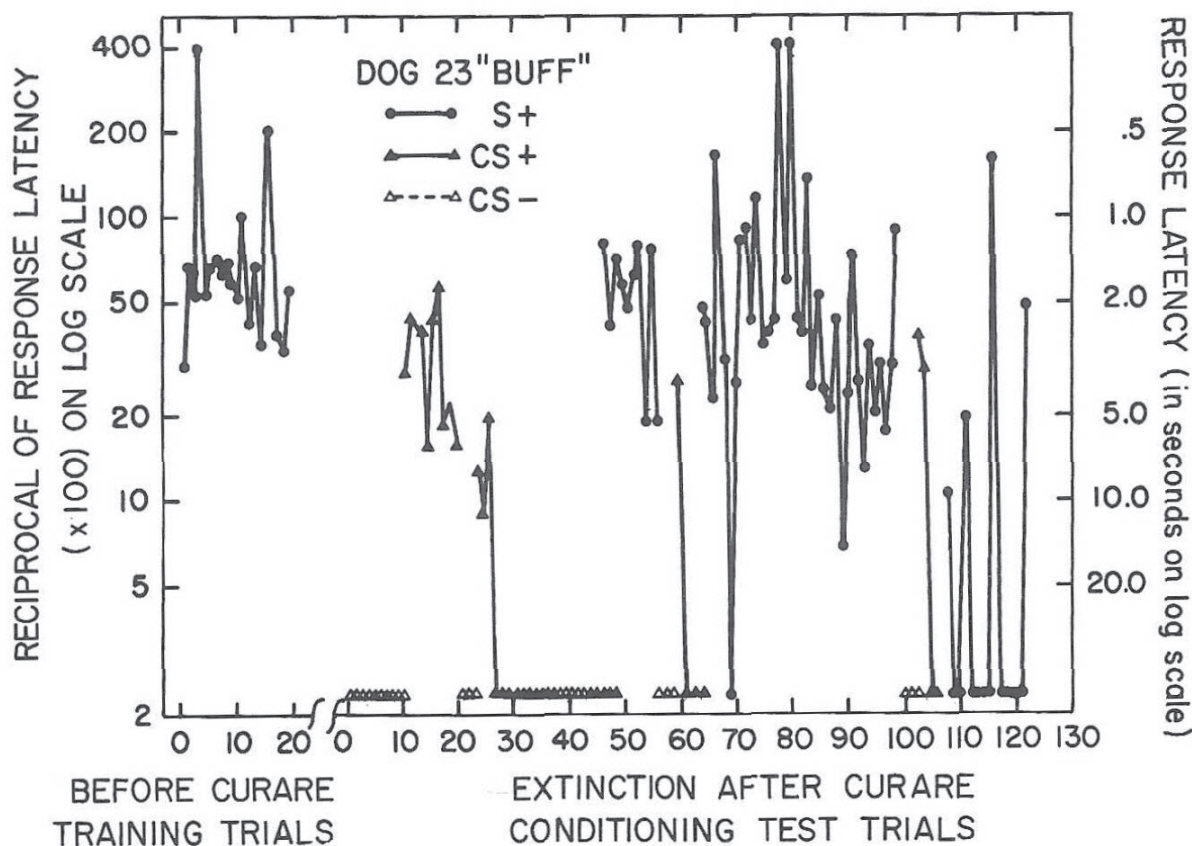

FIG. 10–3.   Control of instrumental avoidance responding by CS's not present during avoidance training but present during a separate Pavlovian fear-conditioning session. Ordinate gives latency of panel-press avoidance response in presence of three different stimuli: (a) the S+, a light used as the danger signal during original avoidance training, (b) CS+, the tonal stimulus always paired with shock during the separate fear-conditioning session, and (c) CS−, the tonal stimulus always presented without a shock during the fear-conditioning session. This figure shows that the first presentation of the CS+ evoked panel-pressing, although the first presentation of CS− did not do so. The successive testing of CS+ under no-shock conditions led to extinction of its evocation power. CS− remained ineffective. In contrast, the S+ retained its evocation power quite well during the long test session.

From: R. L. Solomon & L. H. Turner, "Discriminative Classical Conditioning in Dogs Paralyzed by Curare Can Later Control Discriminative Avoidance Responses in the Normal State," *Psychological Review,* **69,** 1962, Fig. 3, p. 213. Copyright 1962 by the American Psychological Association and reproduced by permission.
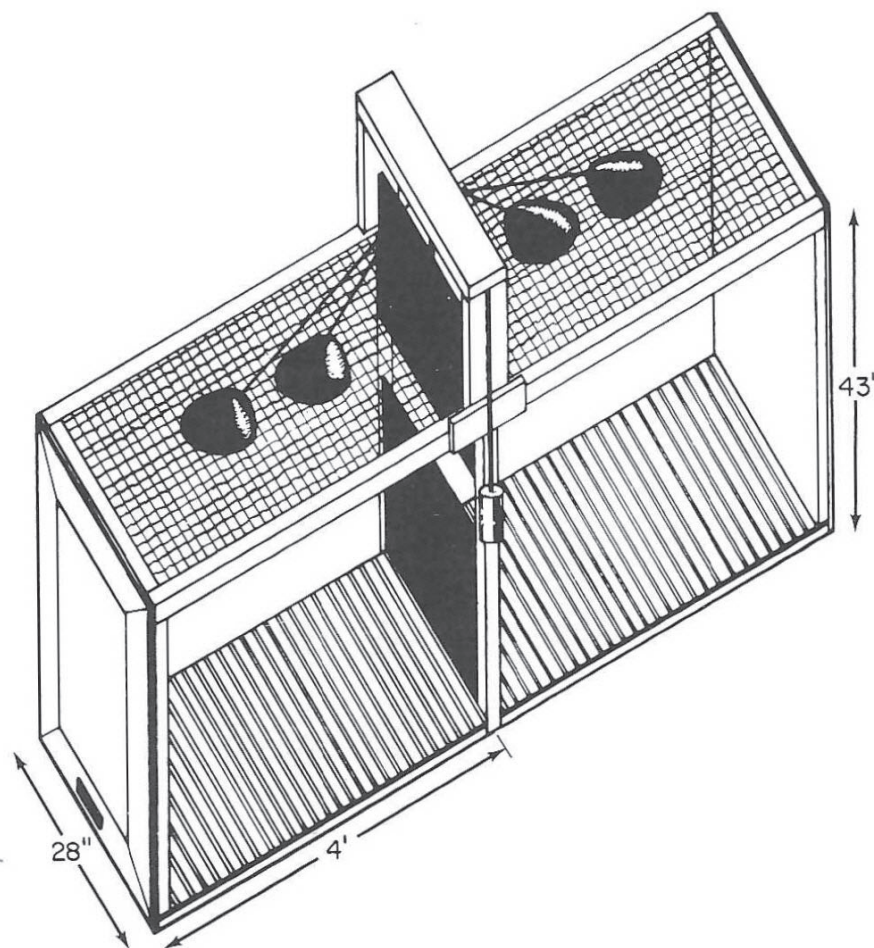
FIG. 10–4.   Schematic diagram of the shuttle box used to train dogs to jump over a barrier in order to escape and avoid shock (see Solomon & Wynne, 1953). Overhead lights can be used as S+. If Pavlovian fear conditioning is carried out in this apparatus, tones are presented by speakers mounted on each end panel. The drop gate is closed during Pavlovian conditioning, preventing escape responses. It is open during escape and avoidance training. The floor of the apparatus is made of steel grid bars for delivery of shocks.

From: R. L. Solomon & L. C. Wynne, "Traumatic Avoidance Learning: Acquisition in Normal Dogs," *Psychological Monographs*, **67** (4, Whole No. 354), 1953, Fig. 1, p. 2. Copyright 1953 by the American Psychological Association and reproduced by permission.

At the time of fear conditioning, the dogs were paralyzed. Therefore, they did not make peripheral skeletal responses which might have been reinforced. Nevertheless, the dogs panel-pressed differentially to CS+ and CS−. Therefore, the instrumental avoidance behavior was probably controlled by Pavlovian contingencies rather than by instrumental contingencies. Adventitious or superstitious reinforcement seems to be a poor explanation for our findings as well as for the Sidman et al. findings.

Nevertheless, consider the possibility that the dogs were trying to press the panel while paralyzed by curare. After all, that is what they had learned to do to escape and avoid shock in the harness. Shock termina-

tion might have adventitiously reinforced such attempts at panel press-ing in the presence of the CS+. This would transform the CS+ into a Skinnerian S^D. This seems to be a plausible alternative to the fear-mediation explanation. Such an explanation cannot, however, easily be maintained in the light of Leaf's (1964) findings. He trained dogs to avoid shock by jumping over a barrier in the shuttle box shown in Fig. 10–4. Then, in a harness located in another room, he subjected them to discriminative Pavlovian fear conditioning while they were paralyzed by curare. A tone (CS+) was consistently paired with shock, and another tone (CS–) was never paired with shock. Then the tones were separately presented to the dogs in the shuttle box 2 days later, and CS+ evoked short-latency jumps while CS– failed to do so.

It seems most unlikely that Leaf's dogs were trying to jump a non-existent barrier while they were being shocked in the harness. This virtually excludes the possibility that barrier jumping was adventitiously reinforced during the discriminative Pavlovian fear conditioning. Leaf's results therefore are excellent preliminary evidence for the mediational postulate of two-process learning theory.

Fear Conditioning Follows the Laws of Pavlovian Salivary Conditioning

Even stronger evidence for the mediational postulate comes from the work carried out in our laboratory by Rescorla and LoLordo (1965), LoLordo (1967), Rescorla (1967), and Moscovitch and LoLordo (1967). We now know that Pavlovian fear conditioning and Pavlovian salivary conditioning obey the same laws. These laws are revealed in the control of avoidance responding by Pavlovian CS's.

Excitation and differential inhibition.   Rescorla and LoLordo (1965) trained dogs to jump a barrier in a shuttle box to avoid shock on a Sid-man schedule. Then they penned the dogs in one side of the shuttle box and carried out discriminative Pavlovian fear conditioning. A tone (CS+) was paired with shock, and another tone (CS–) was paired with absence of shock. Later, in a test session, while the dog was jumping reliably, the experimenters inserted a series of 5-second test presentations of CS+ and CS–. The CS+ produced an immediate tripling of the jumping rate. The CS– reduced the jumping rate almost to zero (see Fig. 10–5). This finding is in agreement with a two-process theory of avoidance behavior. Assume that the fear elicited by apparatus cues maintained the normal rate of Sidman avoidance responding (about seven per min. in Fig. 10–5). The CS+, a conditioned excitor of fear, should have augmented the ambient, conditioned fear level when it was added to the apparatus cues.

Because the CS− was paired with absence of shock, it was a differential inhibitor of fear. Therefore, it should have decreased ambient fear. The fact that these two expectations were confirmed means that conditioned fear follows the Pavlovian law of differential excitation and inhibition.

Excitation and conditioned inhibition. Rescorla and LoLordo (1965) trained two other groups of dogs to avoid shock on a Sidman schedule in the shuttle box. Then they subjected one group to a Pavlovian fear-conditioning procedure in which CS+ was followed by shock on one
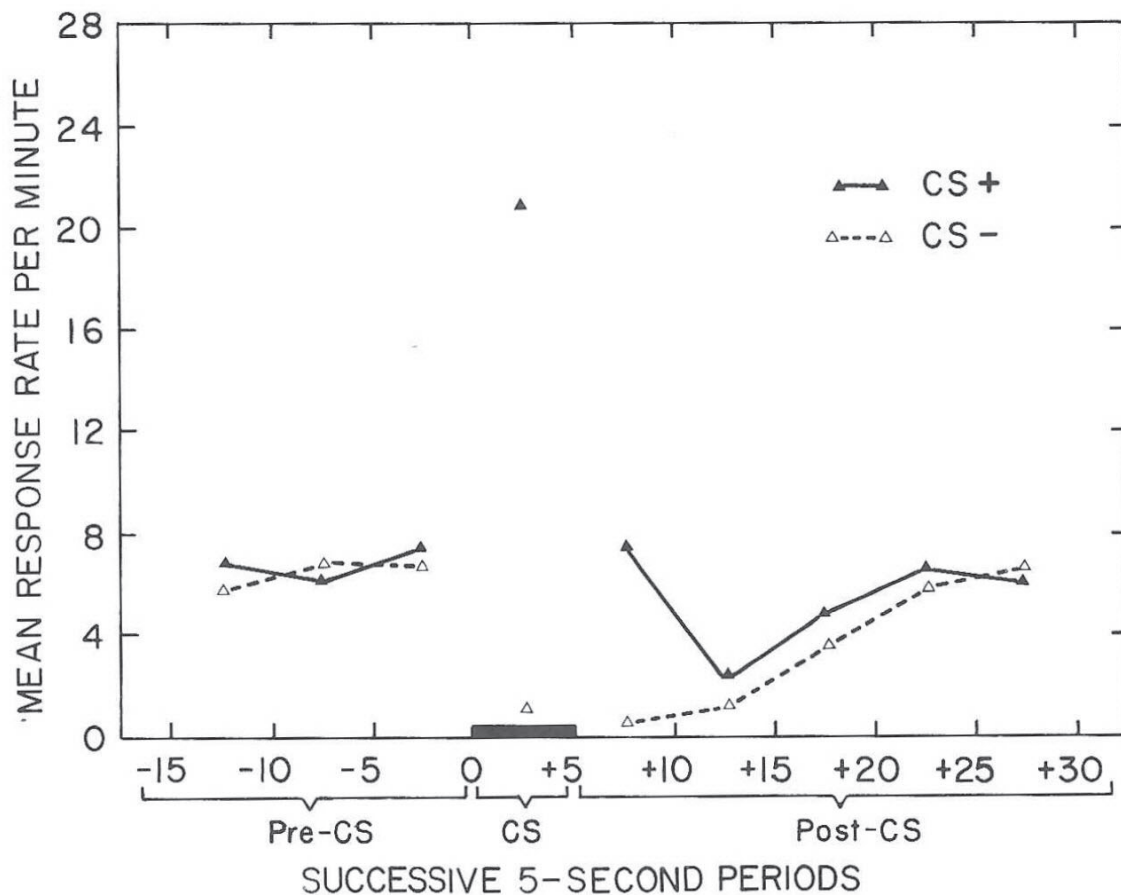

FIG. 10–5. Differential excitatory and inhibitory control of instrumental avoidance responding by a Pavlovian CS+ and CS−. Prior to testing, subjects had been trained under a Sidman contingency to avoid shocks in the shuttle box. Their typical response rate was about 7 per minute. They were then given Pavlovian differential fear conditioning in the same shuttle box. One tone was CS+, a contrasting tone was CS−. Then, in a test session, while subjects were jumping regularly in the shuttle box, 5-second test prods with each CS were given. The ordinate shows jumps per minute. The abscissa shows time before the test prod, during it, and after it. The rates for CS+ and CS− are compared. This figure shows that the CS+ evoked an increase in rate, and then a decrease and increase after CS+ was withdrawn. CS− produced a decrease in rate which slowly subsided after CS− was withdrawn. Thus the recovery from CS+ was biphasic but the recovery from CS− was monotonic.

half of the trials, but on the other half of the trials CS+ was followed by
CS— and no shock. Thus CS— was a temporal substitute for shock. After
learning the Sidman avoidance response, the second group was subjected
to a different Pavlovian fear-conditioning procedure. CS+ was followed
by shock on one half of the trials, but on the other half of the trials CS—
was inserted 5 seconds before the CS+, and no shock followed. The CS—
in both procedures acquired fear-inhibiting properties. Test presentations
of CS— reduced the Sidman avoidance response rate significantly. Pre-
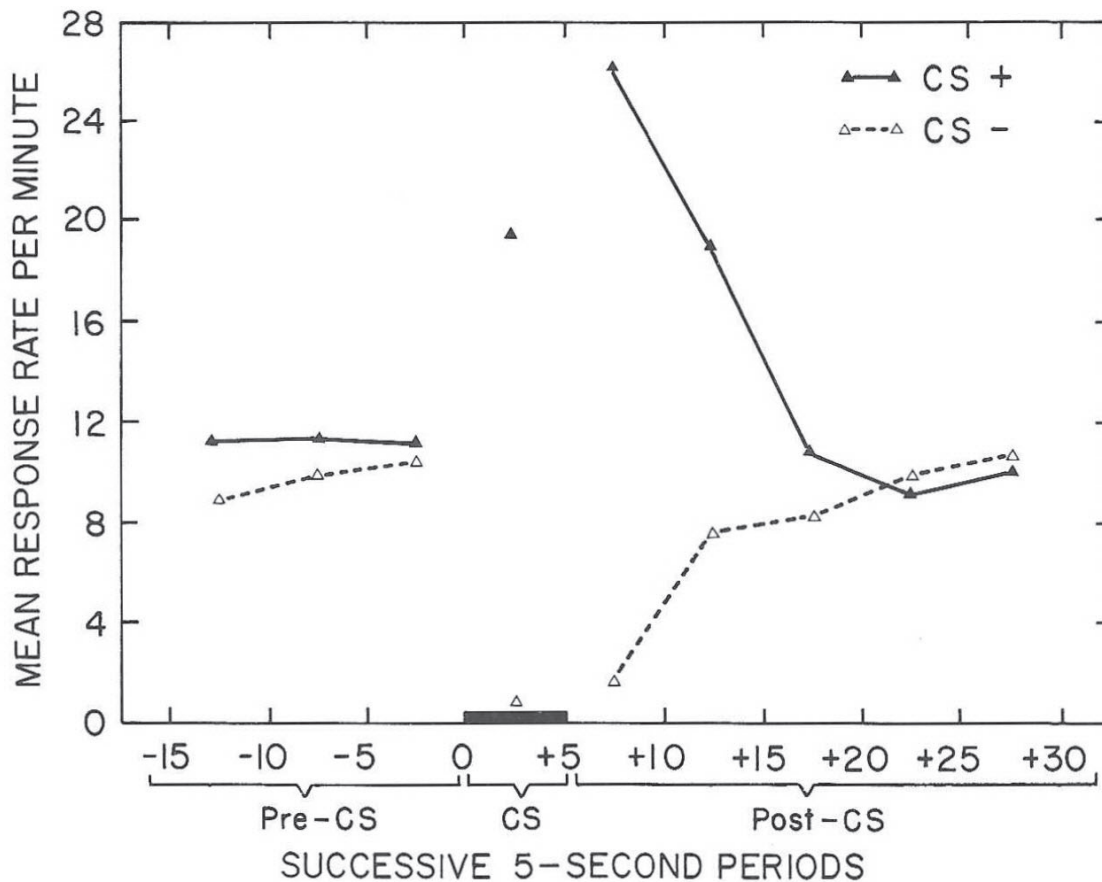sentations of CS+ doubled the response rate (see Fig. 10–6).

FIG. 10–6.   Conditioned excitatory and inhibitory control of instrumental avoidance
responding by a Pavlovian CS+ and CS—. Prior to testing, subjects had been trained
under a Sidman contingency to avoid shock in the shuttle box. Their response rate
stabilized. They were then given Pavlovian fear conditioning in the same shuttle box,
using the Pavlovian conditioned-inhibition procedure. When CS+ occurred alone it
was paired with shock. When CS+ and CS— occurred in sequence, no shock was given.
Then, in a later test session, while subjects were jumping in the shuttle box, test prods
with each CS were given. The ordinate shows jumps per minute. The abscissa shows
time before the test, during it, and after it. The rates for CS+ and CS— are compared.
This figure shows that the CS+ evoked an increase in rate which continued several
seconds after CS+ was withdrawn. The rate subsided monotonically thereafter, until
it reached the pre-CS base line. CS— produced a decrease in rate which slowly subsided
after CS— was withdrawn. Thus the recovery from both the CS+ and the CS— pre-
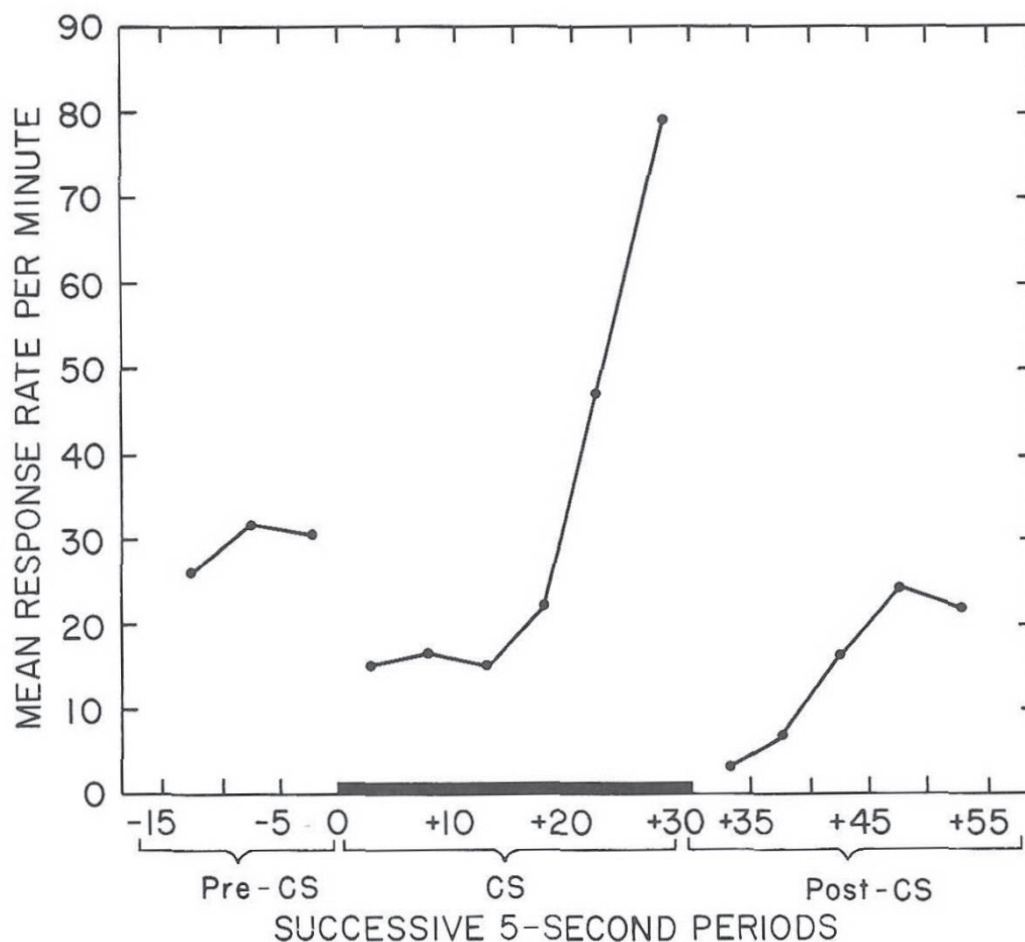sentations was monotonic.

FIG. 10–7. Inhibition by temporal delay. After avoidance training in the shuttle box under a Sidman schedule, subjects were given simple Pavlovian fear conditioning with a 30-second CS–US interval. There was no CS–. In the test session, while subjects were jumping at a regular rate in the shuttle box, the CS+ was presented from time to time. This figure shows that the onset of CS+ produced a decrease in jumping rate. Then, while CS+ continued, the rate increased until it went above the pre-CS baseline rate. Recovery from the 30-second test prod was biphasic.

From: R. A. Rescorla, "Inhibition of Delay in Pavlovian Fear Conditioning," *Journal of Comparative and Physiological Psychology*, 64, 1967, pp. 114–120. Copyright 1967 by the American Psychological Association and reproduced by permission.

Inhibition by temporal delay. Rescorla (1967) trained dogs to avoid shock on a Sidman schedule in the shuttle box. When the dogs had acquired a stable jumping rate, they were subjected to a Pavlovian fear-conditioning procedure in which a 30-second tone (CS+) was followed by shock. Later, while the dogs were performing their avoidance response in the shuttle box, the 30-second tone was presented from time to time. The effects of the tone are shown in Fig. 10–7. The onset of the tone produced a decrease in jumping rate, and in the continued presence of the tone the rate gradually increased. At about 20-second tone duration, the jumping rate went above the normal base-line rate, increasing steadily to the end of the interval, at which time the rate had approximately

doubled. Cessation of the tone produced a decrease in jumping rate to a level below the normal base-line rate, followed by slow recovery to the base line rate. The generality of this finding is illustrated by the results in Fig. 10–8. Rescorla (1967) trained dogs to panel-press in the Pavlov harness shown in Fig. 10–1, using Sidman contingencies. When the dogs were pressing at a stable rapid rate, they were given Pavlovian delayed conditioning using a 30-second tone as CS+ and a shock as US. Later, while the subjects were panel pressing, test presentation of the CS+ produced a decrease in responding followed by a gradual increase throughout the CS+ presentation until the rate had doubled (see Fig. 10–8). Here is a
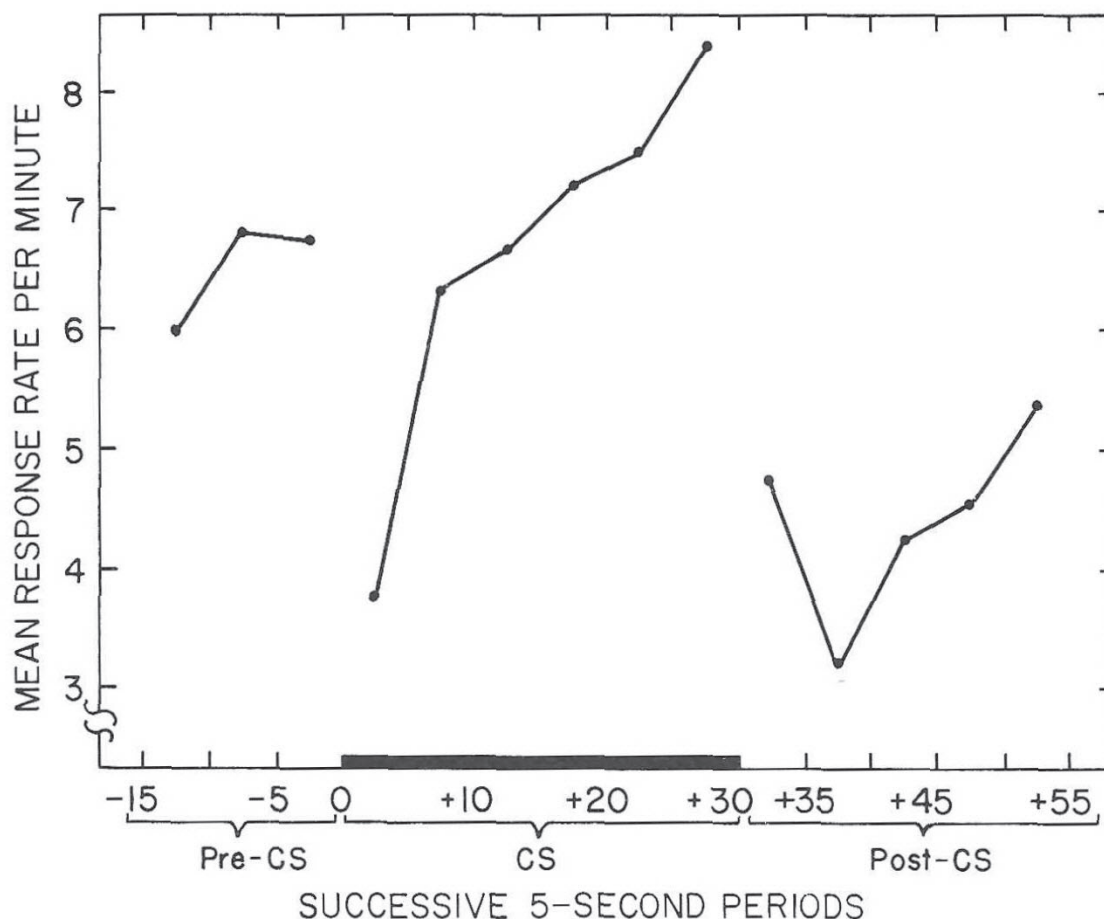
FIG. 10–8.   Inhibition by temporal delay. Subjects were avoidance trained in the Pavlov harness under a Sidman schedule. When they reached a stable panel-pressing rate of about 30 per minute, they were given simple Pavlovian fear conditioning with a 30-second CS–US interval. There was no CS–. In the test session, while subjects were panel-pressing, the CS+ was presented from time to time. This figure shows that the onset of CS+ produced a decrease in panel-pressing rate. Then, while CS+ continued, the rate increased until it went above the pre-CS base-line rate. Recovery from the 30-second test prod was biphasic. The outcome was similar in most respects to that shown in Fig. 10–7.

case in which onset of a danger signal decreased avoidance responding. Pavlov found similar inhibition of delay with salivary CR's and long-duration CS's. He argued that the onset of the CS+ is never closely paired with US and functions as a CS−, inhibiting conditioned reflexes. Rescorla's results show that the law of inhibition of delay holds for fear conditioning.

Inhibition from backward conditioning. Backward conditioning might be considered a prime example of an inhibitory Pavlovian procedure. The CS should become inhibitory provided that the intertrial interval is long, because the CS is followed by a US-free time interval. Moscovitch and LoLordo (1967) found this to be true for fear conditioning. They trained dogs to avoid shock on a Sidman schedule in the shuttle box. Then the dogs were penned in one side of the shuttle box and given backward Pavlovian fear conditioning with a tone and shock. The US–CS sequences were followed by a shock-free, variable intertrial interval with a mean of 2.5 minutes. Later, in a test session, short presentations of the tone resulted in a temporary decrease in jumping rate (see Fig. 10–9). We can infer that the backward CS was an inhibitor and therefore reduced the ambient level of fear. This finding confirms Pavlov's belief that backward excitatory conditioning does not occur.

Inhibition by extinction below zero. Pavlov found that a CS+ once paired with a US, took on inhibitory properties after prolonged extinction. It would be interesting to know whether a CS+ for shock, after it has been thoroughly extinguished, would decrease the rate of Sidman avoidance responding. This experiment has not been carried out.

Generalization of excitation and inhibition. Pavlov implied that all gradients of generalization of inhibition are steeper than those of excitation when he postulated that inhibition is transitory relative to excitation. It would therefore be important to determine the shapes of generalization gradients independently for CS+ and CS−. This work recently was carried out in our laboratory by Dr. Otello Desiderato (1969), and Pavlov's expectations were confirmed. There is a true inhibitory gradient for conditioned inhibition of fear.

Induction. Not much is known about the effect of Pavlovian induction procedures on aversive instrumental responding. One might measure the increase in jumping rate produced by (1) a CS+ presentation that followed a CS− presentation, as compared with (2) a CS+ presentation that followed another CS+ presentation. If positive induction were to occur, the jumping rate would be faster to a CS+ that was preceded by a CS− than to a CS+ that was preceded by a CS+. This experiment has
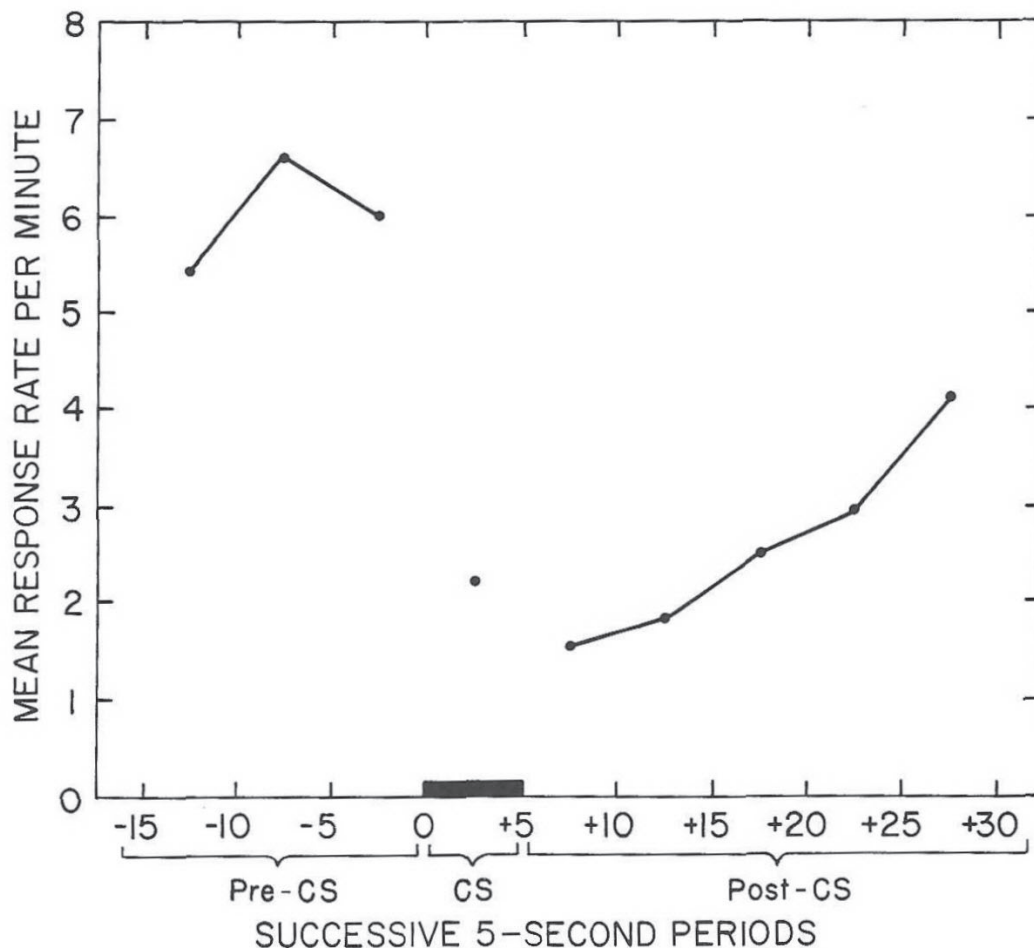
FIG. 10–9.   Inhibition from backward conditioning. After Sidman avoidance train-
ing in the shuttle box, subjects were given backward Pavlovian fear conditioning in
the same shuttle box. There were US–CS pairings followed by long intertrial intervals.
Then, during a later test session, while subjects were jumping at a stable rate, 5-second
test prods with CS were given from time to time. This figure shows that the presence
of the CS produced a decrease in jumping rate. Removal of the CS produced a mono-
tonic recovery to the baseline rate. Thus a backward CS can be an inhibitor of fear.

From: A. Moscovitch & V. LoLordo, "Backward Conditioning and Cessation Con-
ditioning Produce Inhibition," paper presented at the meeting of the Eastern Psycho-
logical Association, Boston, April, 1967. Reproduced by permission.

not yet been done. Negative induction could also be studied. One would
compare avoidance responding to a Pavlovian CS− when it has recently
been preceded by a CS+ presentation, as compared with its being pre-
ceded by a CS− presentation. If negative induction were to occur, the
jumping rate would be slower to a CS− that was preceded by a CS+
than to a CS− that was preceded by a CS−.

External inhibition and disinhibition.   The influence of novel stimuli
upon the power of CS's which are presented during ongoing instrumental
behavior has not been studied. It would be of interest to see whether a
novel (but not aversive) stimulus could disrupt the usual energizing

effect which an aversive CS+ has upon instrumental avoidance behavior (external inhibition). Likewise, we would like to know whether we can remove the inhibitory effect which a CS− has upon instrumental avoidance behavior by presentation of a novel (but not aversive) stimulus (disinhibition).

Other Procedures Affect Conditioned Fear

In the preceding section we showed that fear conditioning obeys the established laws of salivary conditioning. Now we examine other conditioning variables that are important in the control of fear.

Inhibition from a cessation signal. One relationship not studied by Pavlov, yet of significance to two-process theorists, is that between CS presentation and shock termination. Mowrer (1960) postulated that a cessation signal (a CS inserted shortly before shock terminates) should elicit a relief reaction and thus should be a secondary reinforcer. Actually, evidence on the secondary reinforcing properties of cessation signals is conflicting (see review by Beck, 1961). Furthermore, we do not know whether such signals inhibit fear. To answer this question, Moscovitch and LoLordo (1968) trained dogs to avoid shock with a Sidman contingency in a shuttle box. Then the dogs had a Pavlovian conditioning session, during which 4-, 5- and 6-second shocks were presented in a random sequence. A CS was always presented 1 second before each shock termination and it stayed on for 4 seconds. The shock-free intertrial intervals were either 2.0, 2.5, or 3.0 minutes. Later, in a test session, while the dogs were jumping in the shuttle box, test presentations of the CS produced a small but significant decrease in jumping rate (see Fig. 10–10).

Did the cessation signal inhibit fear during Sidman avoidance responding because it had been paired with termination of shock during conditioning? Or did it inhibit fear because it predicted at least 2 minutes of shock-free time? To answer these questions, Moscovitch and LoLordo (1968) compared the fear-inhibiting properties of backward CS's and cessation CS's. For all dogs the CS predicted the same amount of shock-free time during fear conditioning. There were, however, three experimental groups which differed in the relation between the CS onset and shock termination. In a cessation-signal group, the CS came on 1 second before the shock terminated. In two backward conditioning groups, the CS came on either 1 second or 15 seconds after termination of shock. It was found that the CS in both backward conditioning groups reduced the rate of Sidman avoidance responding more than the CS in the cessation–signal group. This means that the backward CS's were more fear inhibiting than the cessation CS.
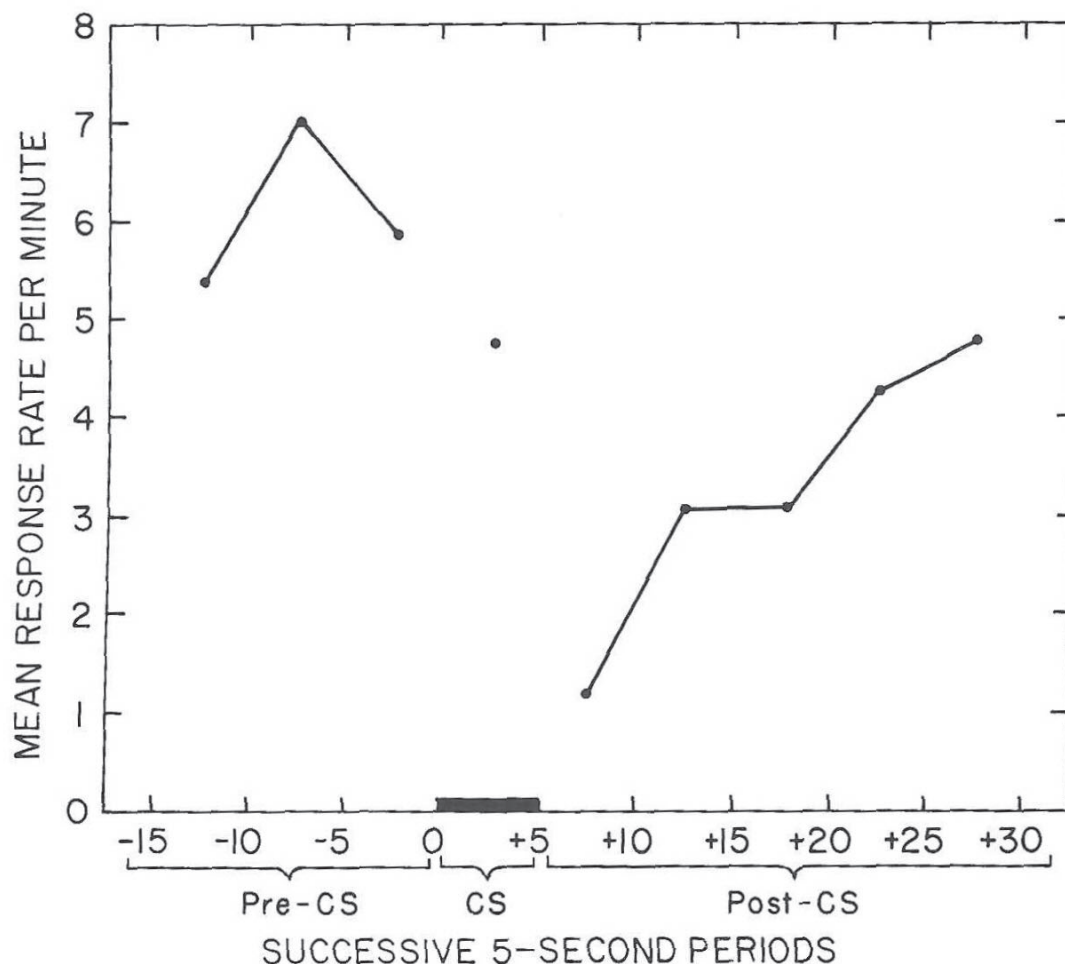
FIG. 10–10.   Inhibition from a cessation signal. After subjects had been trained to jump in the shuttle box in order to avoid shock on a Sidman schedule, they were given a Pavlovian conditioning session. The CS was presented during a 5-second shock. Its onset was 1 second before shock termination. CS duration was 5 seconds. There was no CS signalling the onset of shock. Later, in a test session, 5-second prods with the CS were presented from time to time, while subjects were jumping in the shuttle box. This figure shows that the presence of the CS produced only a slight decrease in jumping rate. However, removal of the CS produced a large decrease in rate followed by slow return to the baseline, pre-CS rate. Thus recovery from the CS test was biphasic.

From: A. Moscovitch & V. LoLordo, "Backward Conditioning and Cessation Conditioning Produce Inhibition," paper presented at the meeting of the Eastern Psychological Association, Boston, April, 1967. Reproduced by permission.

This result is paradoxical because the cessation signal predicts both shock termination and 2.0 minutes of shock-free time, while the backward CS's merely predict shock-free time. There is a theoretical resolution of this paradox. Assume that the cessation signal acquired fear-inducing properties because of its temporal overlap with shock. Assume further that this fear-inducing property summated with the fear-reducing properties of prediction of shock termination. Then the backward CS's should have been more fear inhibiting than the cessation CS.

The information value of a cessation CS may be important (Seligman, 1966). If so, then the amount of uncertainty the animal has about the duration of each shock should determine the amount of relief produced by a cessation CS. This suggests an experiment in which, during a fear-conditioning session, the durations of shocks should be more variable than those used by Moscovitch and LoLordo. The CS should reliably predict shock termination. Such a CS might have powerful fear-inhibiting properties and therefore would, if imposed on the subject during Sidman avoidance, greatly reduce the response rate.

Generalization of fear across different US's.   If subjects were trained to avoid shock, then were conditioned to fear a stimulus paired with a loud noise, would the CS+ for the noise US have the capacity to raise the shock-avoidance rate? Would the CS— for the noise suppress the shock-avoidance rate? LoLordo (1967) trained dogs in a harness to press a panel to avoid shock on a Sidman contingency. Pavlovian conditioning was carried out "on the base line"; i.e., while the dogs were regularly avoiding shock by panel pressing. The conditioning was discriminative, a CS+ being paired with a loud noise (US) and a CS— paired with no noise. Another group of dogs was conditioned "on the base line" with a CS+ paired with shock and a CS— paired with no shock. The CS+ for the loud noise US acquired excitatory properties; test presentations of it increased the panel-pressing rate. The CS+ for the shock US increased the panel-pressing rate more than did the CS+ for the loud noise. The CS— for shock decreased the panel-pressing rate (therefore showing differential inhibition, in confirmation of the earlier shuttle-box avoidance data of Rescorla and LoLordo). However, the CS— for the loud noise did not decrease the panel-pressing rate.

LoLordo (1967) concluded that both the CS+ for loud noise and the CS+ for shock elicited fear. When the CS+ for loud noise was imposed on the subject while it was avoidance responding, it added to the ambient level of fear and thus increased the response rate. However, we do not understand why the CS— for loud noise did not inhibit fear and decrease the avoidance response rate.

This experiment suggests that the mediational properties of aversive CR's can generalize somewhat across different aversive US's. To this extent, fear of shock and fear of a loud noise summate.

Perseveration of excitation derived from aversive US presentations.
Pavlov (1927, p. 59) noted that presentations of meat powder between trials, without pairing them with the CS, enhance salivation to the next presentation of CS+ in well-conditioned dogs. Baum (1967) found similar results with conditioned fear in dogs. The dogs were trained to avoid shock on a Sidman contingency in a shuttle box. Then they were penned up in one side of the shuttle box and were given a series of inescapable

shocks. At varying time intervals following the last inescapable shock, the dogs were released and allowed to jump as usual in the shuttle box. The inescapable shocks resulted in greatly increased jumping rates which persisted in some subjects for as long as 35 minutes after the last shock was received. The rates were a monotonic, decreasing function of time since the last inescapable shock. We interpret this to mean that, in a well-trained subject, inescapable shocks produce a transient state of increased fear. Since the rate of Sidman avoidance responding is directly related to ambient fear level, Baum's results seem reasonable. Studies of this type illuminate the role of performance variables in the control of avoidance responding.

US duration and conditioned fear.   What should be the effects of a long-duration US paired with a CS+ as compared with a short-duration US paired with a CS+? We could adopt an S–S drive-induction view and argue that the CS-onset–US-onset relation is all-important (see Mowrer & Solomon, 1954) and that US duration is irrelevant for fear conditioning. Or, we could take a drive-reduction view of conditioning (see Miller, 1951) and argue that a long-duration US represents a long delay of drive-reduction. Such a view would predict better fear conditioning with a short-duration US. Finally, we could argue that a long-duration US is more severe than a short one (see Church et al., 1966) and should produce better fear conditioning than would a short one.

Overmier (1966) trained dogs to avoid shock in a shuttle box whenever a visual S+ was presented. Then the dogs were given Pavlovian aversive conditioning. Conditioning occurred either while the dogs were curarized in the harness or penned up on one side of the shuttle box. One tone (CS_{S+}) was paired with a 0.5-second shock; a contrasting tone (CS_{L+}) was paired with a 50.0-second shock. Later, when the dogs were undergoing avoidance extinction in the shuttle box, test presentations of the two CS's resulted in shorter jump latencies to CS_{L+} than to CS_{S+}. The subjects jumped almost as quickly to both CS's as they did to the original S+, even though the CS's had never been present during the avoidance training (see Fig. 10–11).

We can conclude that a CS+ paired with long-duration shocks is a better conditioned fear-elicitor than is a CS+ paired with short-duration shocks.

The Problem of Independence of Fear Conditioning and Instrumental Learning

We have argued that fear conditioning mediates instrumental avoidance responding and that the laws that govern fear conditioning are identical
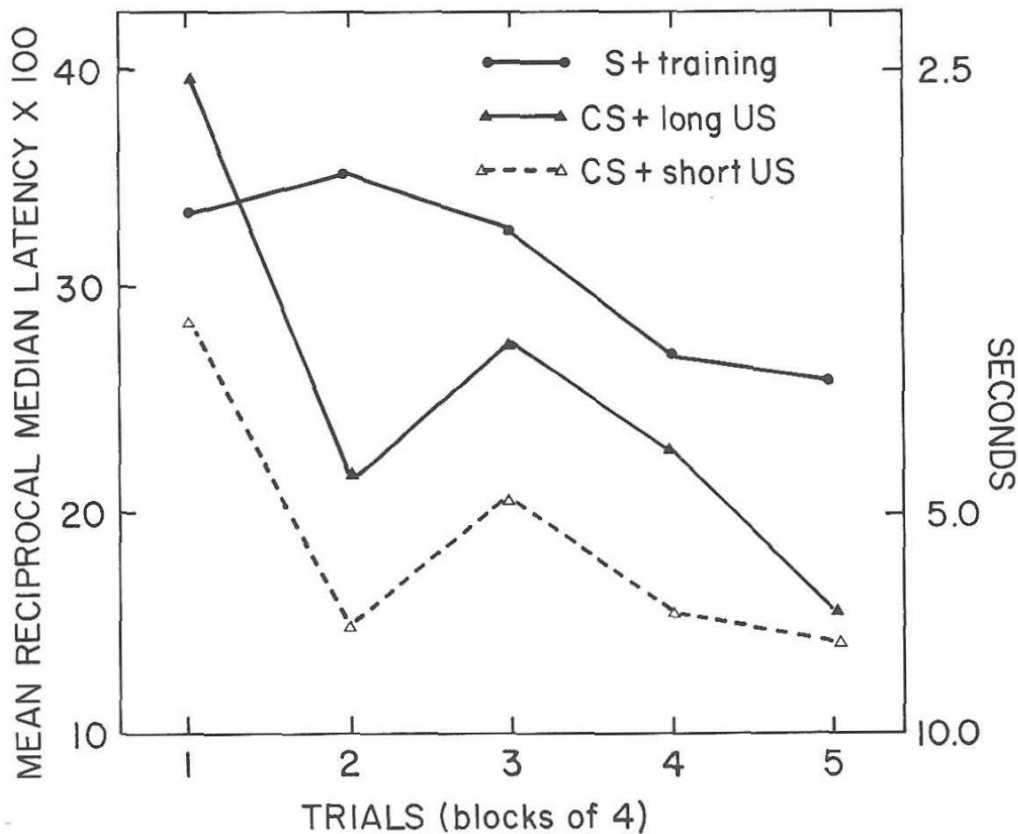
FIG. 10–11.   The effects of US duration during Pavlovian fear conditioning. Subjects had been trained to jump in order to avoid shock in the shuttle box whenever a visual S+ was presented. Then they were given discriminative Pavlovian fear conditioning with one CS+ paired with a long-duration shock and a contrasting CS+ paired with a short-duration shock. Later, in a test session, each CS+ was presented from time to time. This figure shows that, in a series of 20 tests of each stimulus, the CS+ paired with the long-duration shock evoked jumping with shorter latencies than did the CS+ paired with the short-duration shock. The S+ used in original avoidance training maintained its evocation power during the extinction testing better than the two Pavlovian CS's did.

From: J. B. Overmier, "Instrumental and Cardiac Indices of Pavlovian Fear Conditioning as a Function of US Duration," *Journal of Comparative and Physiological Psychology,* **62**, 1966, Fig. 2, p. 18. Copyright 1966 by the American Psychological Association and reproduced by permission.

to those governing Pavlovian salivary conditioning. All of the experiments which have shown this were carried out in two distinct stages: avoidance training, and then Pavlovian fear conditioning. We have obviously taken great pains to separate the administration of Pavlovian CS–US contingencies from the occurrence of Thorndikian response-reinforcement contingencies in these experiments. Pavlovian aversive conditioning operations were usually separated from the avoidance training operations both in time and in space. In such experiments, Pavlovian CS's took control of avoidance responding on their very first presentation in the avoidance situation. There had been no apparent chance for the

Pavlovian CS+ to have become an S+ for the avoidance operant, nor for the Pavlovian CS− to have become an S−.

Nevertheless, Leaf (1964) and Overmier and Leaf (1965) thought it important to test this assumption further. They pointed out that in the experiments successful in showing the control of avoidance responses by aversive Pavlovian CS's, the instrumental avoidance training had been administered first and the Pavlovian aversive conditioning had been second. Leaf reasoned that if this order were reversed there would exist no already established, and situationally appropriate, avoidance response for the CS+ to control during the conditioning procedure. Therefore, the CS+ could not serve as an S+ for the appropriate operant. Leaf gave naive dogs a Pavlovian discriminative fear-conditioning session while they were curarized in the harness. Three days after this discriminative conditioning, the subjects were taken to another experimental room where they received avoidance training in a shuttle box. After learning, they were tested with a random series of presentations of CS+ and CS−. Both stimuli evoked jumping responses, but the CS+ produced shorter latencies than did the CS−. Because discriminative fear conditioning had preceded avoidance learning, we can be further assured that instrumental contingencies were not responsible for this discriminative control.

Later, Overmier and Leaf (1965) compared the precision of discriminative control of fear for these two orders of events: (1) fear conditioning followed by avoidance training, and (2) avoidance training followed by fear conditioning. One group of dogs received one order of events, and another group received the other order. All subjects in both groups showed immediate, discriminative avoidance responding when they were tested during avoidance extinction with presentations of the Pavlovian CS+ and CS−. However, the sharpness of discrimination was better for the subjects having avoidance learning first than it was for subjects having Pavlovian conditioning first. In addition, the subjects having Pavlovian conditioning first showed a marked extinction trend to all test stimuli over 10 days of testing. In contrast, the subjects having avoidance training first showed no decrement in response to any test stimuli as extinction progressed.

This result requires some supplementary principles not inherent in current two-process learning theories. Although the mediation postulate was again confirmed, order made a difference. This means that Pavlovian fear conditioning and instrumental avoidance learning are not completely orthogonal. A complete two-process theory must therefore contain principles of sequential interaction of fear conditioning and avoidance learning.

There is yet another, and quite unexpected, way in which these two experiments take us beyond existing theory. Leaf (1964) and Overmier

and Leaf (1965) [5] noticed that when Pavlovian fear conditioning preceded avoidance training by less than two days, the subjects were initially poor in escaping shock during avoidance training. Sometimes these subjects did not escape shock at all. Aversive Pavlovian conditioning thus can have decremental effects on *to-be-learned* escape and avoidance responses, whereas aversive Pavlovian conditioning has incremental effects on *already learned* avoidance responses. The second section of this paper will examine the nature and cause of the decremental effects.

Learned Helplessness: In Pavlovian Conditioning the US and Instrumental Responding Are Independent; Conditioning Disrupts the Acquisition of Escape and Avoidance

Pavlovian conditioning, by its very nature, establishes a relation between emitted instrumental responding and the US, as well as a relation between CS and US. The relationship between the US and instrumental responding is one of independence; responding neither increases nor decreases the probability of US onset or termination. In other words, the US is inescapable and unavoidable in aversive Pavlovian conditioning. This inescapability of an aversive US interferes profoundly with the subsequent acquisition of instrumental escape and avoidance behavior.

Producing Interference

When an experimentally naive dog receives escape–avoidance training in the shuttle box, the following behavior typically occurs: At the onset of the first electric shock, the dog runs frantically about, defecating, urinating, and howling, until it accidentally scrambles over the barrier and so escapes the shock. On the next trial, the dog, running and howling, crosses the barrier more quickly than on the preceding trial. This pattern continues until efficient avoidance behavior finally emerges. Overmier and Seligman (1967) and Seligman and Maier (1967) found a striking difference between this pattern of behavior and that exhibited by dogs given prior inescapable electric shocks (either unsignaled or preceded by a CS). Such a dog's first reactions to shock in the shuttle box are much the same as those of a naive dog. However, in dramatic contrast to a naive dog, a dog which has experienced inescapable shocks prior to avoidance training soon stops running and howling and remains silent until shock

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[5] Overmier, J. B., & Leaf, R. C. Personal communication.

terminates. The dog does not cross the barrier and escape from shock. Rather, it seems to give up and passively accept the shock. On succeeding trials, the dog continues to fail to make escape movements and will take as much shock as the experimenter chooses to give.

There is another peculiar characteristic of the escape and avoidance behavior of dogs which have first experienced inescapable shock. Such dogs occasionally jump the barrier and escape or avoid, but then revert to taking the shock; they fail to profit from exposure to the barrier-jumping-shock-termination contingency. In naive dogs a successful escape response is a reliable predictor of future, short-latency escape responses.

We have studied the escape–avoidance behavior of 82 dogs which had received prior inescapable shocks. Two-thirds of these dogs do not escape; the other third escape and avoid in normal fashion. In contrast, only 6% of experimentally naive dogs fail to escape in the shuttle box. So any given dog will either fail to escape on almost every trial or will learn normally. An intermediate outcome is rare.

A typical experimental procedure which produces failures to escape shock is as follows. On the first day, the subject is strapped into the Pavlov harness and given 64 inescapable electric shocks, each 5.0 seconds long and of 6.0-ma. intensity. The shocks occur randomly in time. Twenty-four hours later, the subject is given 10 trials of signalized escape–avoidance training in the shuttle box. The onset of the CS (dimmed illumination) begins each trial, and the CS remains until trial termination. The CS–US interval is 10 seconds. If the subject jumps the barrier (set at shoulder height) during this interval, the CS terminates and no shock occurs. Failure to jump during the CS–US interval leads to a 4.5-ma. shock which remains until the subject jumps the barrier. If the subject fails to jump the barrier within 60 seconds after CS onset, the trial automatically terminates, and a 60-second latency is recorded.

The shuttle-box performance which typically results is plotted in Fig. 10–12, which presents the median latency of barrier jumping on each of the 10 escape–avoidance trials for a group ($N=82$) pretreated with inescapable shocks and a naive control group ($N=35$). The group pretreated with inescapable shocks responds much more slowly than does the group not so pretreated. Sixty-three percent of dogs pretreated with inescapable shock fail to escape on nine or more of the ten trials. Only 6% of naive dogs fail to escape on nine or more of the ten trials. Remember that failure to escape means that the dog takes 50 seconds of severe pulsating shock on each trial.

The interference effect is very general. It does not depend solely on the use of any particular shock parameters. Overmier and Seligman (1967) and Seligman and Maier (1967) varied frequency, intensity, density, duration, and temporal pattern of shocks, and still produced the interference
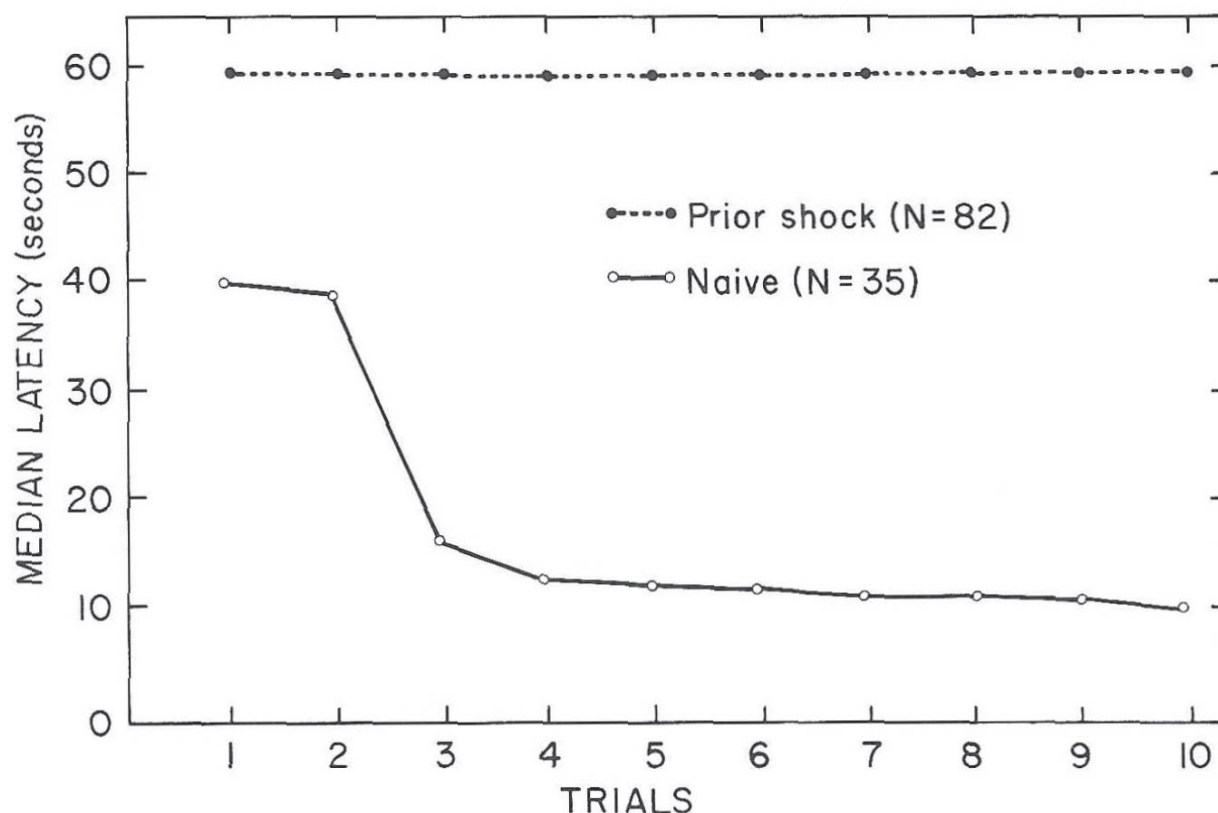
FIG. 10–12.   The effects of inescapable shocks in the Pavlov harness on escape re-
sponding in the shuttle box. This figure shows that there is rapid escape learning by
35 naive dogs which received no shocks in the harness. In contrast, the median for 82
dogs which received inescapable shocks in the harness, prior to escape training in the
shuttle box, shows failure to escape shock. The arbitrary failure criterion was 50 seconds
of shock (a latency of 60 seconds after onset of the S+).

effect. Furthermore, it does not matter if the inescapable shock is or is
not preceded by a CS. Finally, it does not matter where the inescapable
shocks are given and where the escape–avoidance training takes place.
The shuttle box and harness are interchangeable.

Explanations of the Interference Effect

Explaining the interference effect is not easy. Here are some conventional
hypotheses which we considered and rejected, together with a new hy-
pothesis which we have confirmed in several ways.

Adaptation.   The adaptation hypothesis maintains that a subject
adapts to shock during pretreatment with inescapable shocks and is
therefore not sufficiently motivated to escape from shock in the shuttle
box. The hypothesis is inadequate: (1) Adaptation to repeated, intense
shocks has never been demonstrated (Church et al., 1966). (2) It is un-
likely that very much adaptation could persist for as long as 24 hours.

(3) The dogs do not look as though they are adapted; they howl, defecate, and urinate to the first shock presentation in the shuttle box. On later trials, the dogs are passive; but they whimper and jerk with the shock. (4) We have disconfirmed the adaptation hypothesis experimentally. Raising the shock level in the shuttle box should increase motivation to escape. However, Overmier and Seligman (1967) found that increasing the shock level from 4.5 ma. to 6.5 ma. does not eliminate the interference effect. (5) A series of escapable shocks in the harness does not produce failure to escape in the shuttle box (Seligman & Maier, 1967), while the same shocks, if *inescapable*, do produce failure to escape. By this hypothesis, both conditions should lead to equal adaptation to shock and to similar behavior in the test situation, but they do not. (6) Dogs which first escape shock in the shuttle box, then receive inescapable shocks in the harness, later escape and avoid shock normally in the shuttle box (Seligman & Maier, 1967). The inescapable shocks in the harness should produce adaptation to shock, but they do not. (7) Failure to escape can be eliminated by dragging the dog across the barrier in the shuttle box (Seligman, Maier, & Geer, 1967). This exposure of the dog to the escape and avoidance contingencies should not change his degree of adaptation to shock.

Sensitization.   Perhaps the inescapable shocks received in the harness sensitize the subject to shock so that it is too motivated to enable it to make organized responses in the shuttle box. This hypothesis is inadequate. (1) Sensitization explains inefficiency of responding but not the absence of responding. (2) Lowering the shock level in the shuttle box should permit the subject to make organized responses. However, Overmier and Seligman (unpublished data) found that the interference effect is not attenuated when shock in the shuttle box is reduced to 3.0 ma. (3) Arguments (1), (2), and (3) in the previous paragraph, which invalidate the adaptation hypothesis, also invalidate the sensitization argument.

Competing motor responses.   There are three forms which the competing-motor-response explanation takes.

   (1) One form, based on the idea of adventitious reinforcement, maintains that a specific motor response occurs at the moment that shock terminates in the harness. This event reinforces the particular response and increases the probability that it will be present when shock terminates on the next trial. In this manner, the response should acquire great strength. If this response is incompatible with barrier jumping, and if shock elicits it in the shuttle box, then the subject will not jump the barrier.

   This view is weak empirically. We observed the dogs closely and saw

no evidence of superstitious responding. More seriously, the argument is logically unsound. If some response is adventitiously reinforced by shock termination and is thereby more likely to recur, it should be more likely to occur when shock goes on as well as when shock goes off. Thus this response will be punished by shock onset as well as reinforced by shock termination. There is nothing in the adventitious reinforcement notion to suggest that reinforcement will be more effective than punishment. It is, therefore, a mystery why inescapable shock in the harness should establish a specific response. Moreover, even if acquired in the harness, why should the specific response persist in the face of hundreds of seconds of shock during shuttle-box training? It would seem that such a response should disappear. Furthermore, try to imagine a specific response which might have been superstitiously learned in the harness and which would completely prevent barrier jumping in the shuttle box! We doubt that this could be accomplished, even with explicit reinforcement of any specific response in the harness.

(2) A second competing-motor-response hypothesis maintains that active responses are occasionally punished by shock onset. Such adventitious punishment decreases the probability of active responding in the harness, and this transfers to the shuttle box. This hypothesis entails the same logical difficulty as does adventitious reinforcement. Active responding may be adventitiously punished by shock onset, but it should also be reinforced by shock termination. The adventitious punishment hypothesis does not suggest why punishment should be more effective than reinforcement. Furthermore, as active responding is eliminated by punishment, passive responding should increase in frequency. At this point, adventitious punishment should begin to eliminate passive responding, thereby increasing the probability of active responding, and so on. Moreover, even if passive responding were acquired through adventitious punishment in the harness, why should it persist in the face of hundreds of seconds of shock in the shuttle box?

(3) The third version of the competing-motor-response interpretation is that the subject reduces the severity of the electric shocks received in the harness by means of some specific motor response. The transfer of this explicitly reinforced motor response should be mediated by shock in the shuttle box and might interfere with barrier jumping. Because inescapable shocks in the harness are delivered through attached electrodes augmented by electrode paste, it is unlikely that the subject could increase electrical resistance by any particular motor response. It is conceivable, however, that some unknown pattern of muscle tonus or movement may reduce pain. Overmier and Seligman (1967) eliminated this possibility. Their dogs were completely paralyzed by d-tubocurarine during inescapable shocks in the harness, and so could not move or modify their muscle tonus. These dogs subsequently failed to escape shock in the

shuttle box just as do dogs who have received inescapable shocks in the noncurarized state. In contrast, dogs merely curarized in the harness subsequently escaped normally in the shuttle box. If a dog can reduce the severity of shock while curarized, the unknown mechanism for this must be central to the myoneural junction.

This experiment also disconfirms any literal interpretation of the adventitious reinforcement and punishment views. The adventitiously reinforced or punished responses cannot be of a gross, skeletal nature. On the other hand, Black (1967) has shown that electromyographic responses can be explicitly reinforced or punished while the subject is curarized. No one has shown, however, that electromyographic responses in the curarized dog can be established by adventitious reinforcement or punishment. Even if such responses were adventitiously reinforceable, there is no a priori reason to think that they would prevent subsequent barrier jumping in the shuttle box. Finally, it is strange that this type of argument is as widely used as it is (e.g., Herrnstein, 1966; Pinckney, 1967; Sidman et al., 1957). We know of only one demonstration (anecdotal) that any response can be established by adventitious reinforcement (Skinner, 1948) or punishment, although there are a few studies which show that adventitious reinforcement might maintain responses already established by explicit reinforcement.

Emotional exhaustion.   Do the dogs fail to escape from shock because they are emotionally exhausted? This seems plausible because the interference effect has a time course. In all of the experiments discussed so far, 24 hours intervened between the inescapable shocks in the harness and escape training in the shuttle box. Overmier and Seligman (1967) showed that there was no interference effect when escape training came either 48, 72, or 144 hours after inescapable shock. Interference dissipates in time, and this suggests mediation by a time-dependent, physiological state. Perhaps the inescapable shocks produce parasympathetic overshoot (Brush, Myer, & Palmer, 1963; Brush & Levine, 1965). Or, perhaps they produce adrenergic depletion or sympathetic exhaustion.

Simple exhaustion hypotheses are inadequate to explain our findings. (1) The interference effect can be made to last for at least a month. Seligman, Maier, and Geer (1967) showed that if a dog fails to escape in the shuttle box 24 hours after receiving inescapable shocks in the harness, then it will again fail to escape if tested a month later. (2) The dogs are not physically exhausted. They do occasionally jump the barrier during the intertrial interval and at the end of the session in order to leave the shuttle box. They even jump the barrier once in a while during shock, but they do not persist. (3) A series of escapable shocks in the harness does not produce subsequent failure to escape in the shuttle box (Seligman & Maier, 1967). This means that a hypothetical emotional ex-

haustion state does not arise from shock per se. (4) If a naive dog first receives escape training in the shuttlebox, then receives inescapable shocks in the harness, it will later continue to escape normally in the shuttle box. There is no simple reason why emotional exhaustion should be eliminated by prior escape training. (5) Failure to escape shock, once chronic, is curable. Dragging the dog back and forth across the barrier of the shuttle box during the CS and shock exposes the dog to the escape and avoidance contingencies. After many such draggings, the dog will escape shock on his own (Seligman, Maier, & Geer, 1967). If the dog were emotionally exhausted, merely showing him that he can escape and avoid shock should do no good.

Learned helplessness.   Assume that animals acquire expectations about the outcomes of their acts. They learn that responding produces reinforcement. They also learn that responding does not produce reinforcement (extinction). They can even learn that not responding produces reinforcement (differential reinforcement of other behavior, DRO). In a situation where shock is neither escapable nor avoidable such simple relationships do not hold. Shock termination is not dependent on either the occurrence or the nonoccurrence of a response. Sometimes the dog does something and shock happens to terminate. Sometimes the dog does something and shock does not terminate. Sometimes shock terminates when the dog has not done something. The shock programmer is not influenced by the subject. Can an animal learn in this situation, and if so, how can we describe what it is that he learns?

Consider the time interval between shock onset and shock termination to be broken into a series of small time intervals each of duration Δt. Further, assume that Δt is shorter than the duration of any response that the subject may make. No more than one response can occur in any Δt; therefore, Δt can contain only a response or the absence of a response. In addition to a response (or its absence), Δt can contain shock termination. When shock is inescapable, there is a fixed probability of shock termination in any Δt. For example, our use of a shock of 5-seconds duration determines the probability of shock termination. It will be zero for all Δt's during the shock except the last during which the probability is one. Nothing the subject does in any Δt will effect the probability of shock termination in that Δt. Therefore, the contingencies between responding and shock termination are such that for any Δt the conditional probability of shock termination, given any response, is equal to the unconditional probability of shock termination.

Learning theorists have, with few exceptions (e.g., Skinner, 1938, pp. 163–166), considered only the conditional probability of reinforcement, given a response. However, there is another important conditional probability, that of reinforcement in the absence of a response; in general,

reinforcement can occur with any probability when no response is made. When shock is inescapable, this conditional probability is greater than zero. In any Δt it is equal to the unconditional probability of shock termination. It follows that, when shock is inescapable, *the conditional probability of shock termination, given the presence of any response, is equal to the conditional probability of shock termination, given the absence of that response.* Thus, the statement that shock termination is not dependent on responding means that these two conditional probabilities are equal.

We propose that a dog can learn that reinforcement is independent of the presence or absence of responding: "Nothing I do matters." In the case of inescapable shock, the dog learns that shock termination is independent of his behavior. More specifically, we think that the animal is sensitive to the fact that the conditional probability of shock termination, given the presence of any response, does not differ from the conditional probability of shock termination in the absence of that response. Furthermore, we are suggesting that dogs are sensitive to the conjoint variation of these two probabilities. Independence is simply the special case in which these two conditional probabilities are equal.

The procedure of presenting a stimulus independently of the subject's responding is unlike the procedures that most psychologists are used to. It is not an acquisition procedure. In acquisition there is an explicit correlation between a specified response and an outcome. In our procedure there is no specified response and no correlated outcome. It is not an extinction procedure. In extinction procedures some specified response is first strengthened by being correlated with a reinforcing outcome. Then the strengthened response is subsequently weakened by removing the outcome entirely from the experimental treatment. In our procedure this is not the case, because the response (supposedly undergoing extinction) is sometimes correlated with shock termination. Finally, when the experimenter gives the subject inescapable shocks, the procedure is not a partial-reinforcement procedure. In partial reinforcement sometimes the specified response occurs but reinforcement does not occur. Reinforcement never occurs unless the specified response has been made. In our situation shock termination occurs in the absence of a specified response.

Sensitivity to the independence of responding and shock termination could produce the interference effect in the following way: (1) At first the dog makes active responses during shock in the harness. (2) Because shock is inescapable, he learns that shock termination is independent of his behavior. (3) The incentive for the initiation of active responding in the presence of electric shock is partly produced by the expectation that responding will increase the probability of shock termination. When the expectation is absent, the incentive for response-initiation is low. (4) The

electric shock in the shuttle box arouses the same expectation that was learned in the harness (i.e., that shock termination is independent of responding). Therefore, incentive for initiating responses in the presence of shock in the shuttle box is low. So the probability of jumping the barrier is low, as is the probability of doing anything active.

The term *learned helplessness* is a convenient label for the expectational and incentive mechanisms we have described.[6]

The prior learning in the harness that shock termination and responding are independent would be expected not only (1) to reduce incentive for barrier jumping, but also (2) to interfere with the formation of the barrier-jumping shock termination association, should the subject happen to jump the barrier and terminate shock. The prior learning of A-B can interfere with learning A-C. This accounts for the fact that a dog, pretreated with inescapable shock, occasionally jumps the barrier but does not "catch on." A small number of response shock-termination pairings is not sufficient to overcome the previous learning of independence between shock termination and responding.

By this hypothesis it is not shock per se that produces helplessness, but rather it is the subject's lack of control over shock. Therefore, learned helplessness should not result from prior escapable shock. Seligman and Maier (1967) performed the obvious test of this prediction. Three groups of eight dogs each were used. An Escape Group was trained in the harness to press a panel with its nose or head in order to turn off shock. A Yoked Group received shocks identical to the shocks delivered to the Escape Group. The Yoked Group differed from the Escape Group only with respect to the degree of instrumental control over shock. Pressing the panel in the Yoked Group did not affect the programmed shocks. A Naive Control Group received no shock in the harness.

The Escape Group learned to terminate shock in the harness and showed decreasing latencies of panel pressing over the course of the session. Towards the end of the session, the response consisted of a single, discrete head movement following shock onset. Subjects in the Yoked Group typically lay motionless after about 30 trials.

Twenty-four hours following the harness treatment, all three groups

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[6] In this section we are using cognitive terms to describe what is learned. However, in the first section of this paper we used concepts such as conditioned fear and conditioned inhibition of fear to describe performance changes. The reader is entitled to an explanation of this inconsistency. Since the problems covered in Section I have traditionally been described in noncognitive terms, we chose to use noncognitive language. It should be pointed out that concepts like conditioned fear and conditioned inhibition of fear can be translated into cognitive terms such as expectation of shock and expectation of no shock. In this section we face a problem that has not been treated within any theoretical framework. We think the phenomena are most easily understood in cognitive terms. We do not see a simple way of translating our use of expectancy and our explanation of helplessness into the CER, mediational language of Section I. We do not deny the possibility of such a translation.
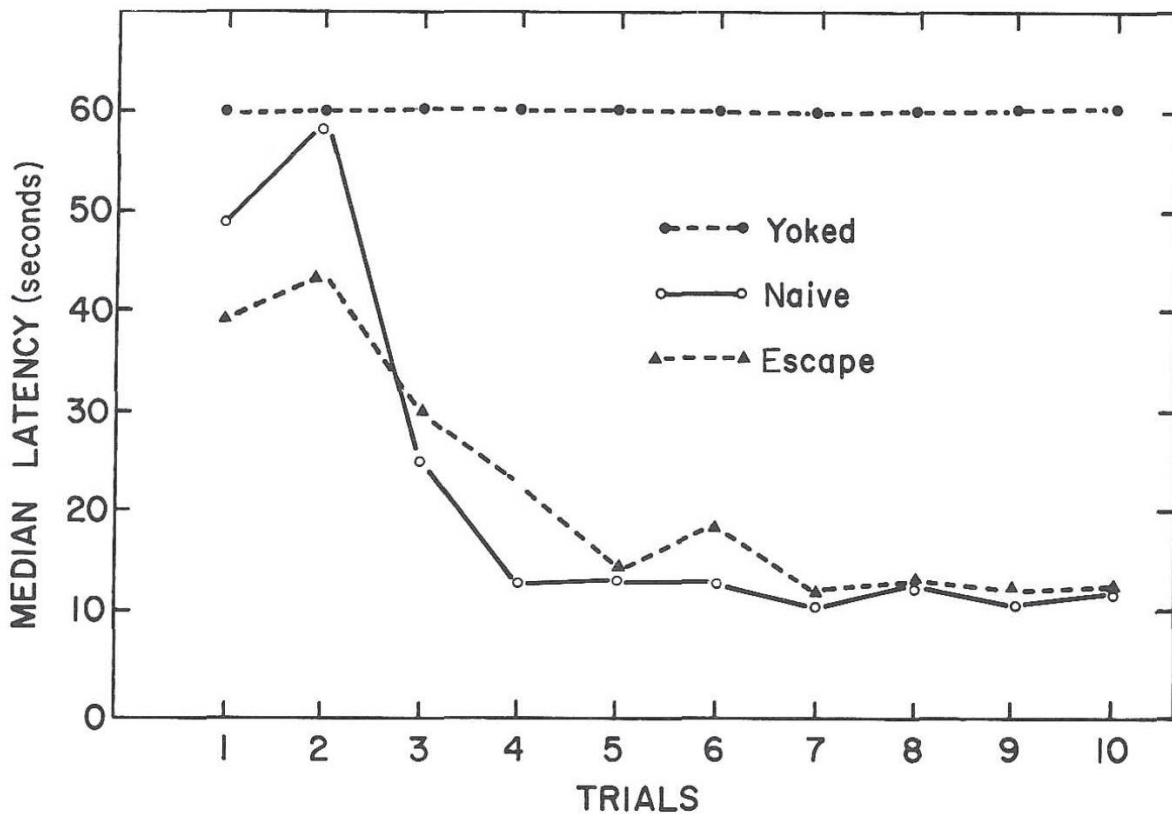
FIG. 10–13.   The effects of matched escapable and inescapable shocks on later escape learning. This figure shows the median escape response latencies in the shuttle box for three groups of dogs: (a) those given escape training in the shuttle box as naive subjects; (b) those given prior escape training in the harness, panel-press apparatus; and (c) those given prior inescapable shocks in the harness, but matched in duration and temporal distribution to the shocks for the panel-press, escape-training group. The arbitrary criterion of failure to jump was a 60-second latency (50 sec. of shock).

received ten trials of escape–avoidance training in the shuttle box. Shuttle-box performance is summarized in Fig. 10–13, which shows the median latency of barrier jumping on each of the ten trials for each of the three groups. The Escape Group did not differ from the Naive Control Group. It suffered no impairment in shuttle-box performance. In contrast, the Yoked Group showed significantly slower latencies than the Naive Control Group. Six of the eight subjects in the Yoked Group failed to escape shock. Thus the helplessness hypothesis was supported. It is not the shock itself, but rather the subject's inability to control shock that produces failure to escape.

Immunizing Against Interference

The helplessness hypothesis suggests a way to immunize dogs against the interfering effects of inescapable shocks. Prior experience with escapable shocks should do two things: (1) interfere proactively with the dog's ex-

pectation that responding and shock termination are independent, and (2) allow the dog to discriminate between the place where shocks are escapable and the place where they are inescapable. The relevant experiment was done by Seligman and Maier (1967). One group of dogs was given ten trials of escape–avoidance training in the shuttle box before they received inescapable shocks in the harness. Interference with subsequent escape–avoidance behavior was eliminated. That is, such a subject continued to respond normally when placed in the shuttle box 24 hours after inescapable shock treatment in the harness.

Another interesting finding emerged. The dogs which first learned to escape shock in the shuttle box pressed the panels four times as often as did naive dogs during the inescapable shocks in the harness. This happened even though pressing a panel had no effect on the shock. Such panel pressing is probably an index of attempts to control shock.

Is it the escapability of the shock in the shuttle box which prevented the interference effect and the enhanced panel pressing, or is it the subjects' freedom of motion during shock? To answer this question, Seligman and Maier (1967) ran a group of dogs receiving ten trials in the shuttle box on the first day of treatment. However, the subjects' barrier jumping and the termination of shock and CS were independent on these ten trials. On the next day, the subjects received inescapable shocks in the harness, followed 24 hours later by escape–avoidance training in the shuttle box. These subjects failed to escape in the shuttle box and panel pressed infrequently in the harness. Thus, control over shock termination is the crucial determinant of the interference effect.

Breaking Up the Interference Effect

If the subject fails to escape in the shuttle box 24 hours after inescapable shocks, the interference effect will persist in a chronic form; the subject will fail to escape on later opportunities. The helplessness hypothesis suggests a way to eliminate chronic failure to escape. By this hypothesis, the dog does not try to escape because he does not expect that any instrumental response will produce shock termination. By forcibly exposing the dog to the escape and avoidance contingencies, this expectation might be altered. This type of training by "putting through" has been used by others with mixed success (Miller & Konorski, 1928; Loucks, 1935; Woodbury, 1942). Seligman, Maier, and Geer (1967) reasoned that forcibly dragging the dog from side to side in the shuttle box, in such a way that the dog's changing compartments terminated shock, might effectively expose the dog to the response–reinforcement contingency. This was the case. The experimenter pulled three chronically helpless dogs back and forth across the shuttle box with long leashes. This was

done during CS and shock, while the barrier was absent. After being pulled across the center of the shuttle box (and thus terminating shock and CS) 20, 35, and 50 times, respectively, each dog began to respond on his own. Then the barrier was replaced, and the subject continued to escape and avoid. The recovery from helplessness was complete and lasting.

The behavior of animals during "leash pulling" was interesting. At the beginning of the precedure, a great deal of force had to be exerted to pull the dog across the center of the shuttle box. Less and less force was needed as training progressed. A stage was typically reached in which only a slight nudge of the leash was required to impel the dog into action. Finally, the subject initiated its own response, and thereafter failure to escape was very rare. The initial problem seemed to be one of "getting the dog going."

Seligman, Maier, and Geer had first tried other procedures with little success. Merely removing the barrier, the experimenter's calling to the dog from the safe side, dropping food into the safe side, kicking the dangerous side of the box—all of these procedures failed. Until the correct response occurs, the dog cannot be exposed to the response–reinforcement contingency. It is remarkable that so many forced exposures were required to "get the dog going." This observation supports our twofold interpretation of the effects of inescapable shock: (1) the incentive for initiating responses during shock is low, and (2) the association of response events and reinforcement is proactively impaired.

Why Does the Interference Effect Dissipate in Time?

As we have mentioned, the interference effect has a time course. Overmier and Seligman (1967) found that if 48 hours or more intervene between inescapable shocks and escape training, the dogs escape normally. In contrast, when a 24-hour interval elapses, dogs fail to escape. In addition, Seligman and Maier (1967) found that if the subject fails to escape shock in the shuttle box 24 hours following inescapable shocks, it will continue to fail at least one month later. Thus, an additional experience with inescapable shock maintains and potentiates the interference effect well beyond the 48-hour interval during which it would otherwise dissipate.

How can we account for this time course? Quite clearly, the helplessness hypothesis alone does not provide for dissipation in time. What mechanism would? The most obvious idea is that shocks per se produce a state of emotional exhaustion from which the dog gradually recovers. We have cited (see pp. 324–325) several lines of evidence to invalidate this simple interpretation. There are, however, three lines of interpretation which, though more complex, seem promising.

Expectation, incentive, and emotional exhaustion. Learning that one's own responses are ineffective in controlling a traumatic situation may produce emotional exhaustion. Weiss (1968) has shown that rats which cannot control shock show more stress, as measured by CER, weight loss, stomach ulcers, and defecation, than do rats which can control shock. The high degree of stress resulting from inescapable shocks might lead to emotional exhaustion. This exhaustion may dissipate in time. Furthermore, like fear, a state of emotional exhaustion might become discriminatively conditioned to external cues. Such a mechanism could explain the perseveration of the interference effect. It is possible that this kind of conditioning occurred when our dogs failed to escape in the shuttle box 24 hours after inescapable shock in the harness. Immunization procedures worked because the emotional exhaustion was discriminatively conditioned only to the harness cues and not to the shuttle box cues. Finally, if emotional exhaustion is produced by the expectation that responding does not control shock, once the dog "sees" a response–reinforcement contingency, emotional exhaustion should disappear. This may be why "dragging" breaks up the interference effect.

Why should inescapable shocks produce more stress than escapable shocks? We lean toward the view that learning that one's responses are independent of traumatic events will itself produce stress over and above that normally caused by the traumatic stimuli themselves. However, there is a good alternative to this explanation. It is possible that learning that one's responses can control traumatic events will reduce the stress normally produced by the traumatic stimuli themselves. With this latter view, one need not postulate that the subject learns that shock is independent of responding. Instead, shock itself sets the level of stress, but learning that one can control shock reduces stress. We have not yet thought of ways of testing directly which of the two positions is correct. There are a number of ways of testing indirectly, and these are described below on pp. 335–337.

There are known physiological mechanisms that might produce emotional exhaustion. We are interested in several of these: (1) exhaustion or inhibition of the adrenergic transmitter involved in the control of aversive motivation; (2) sympathetic exhaustion; and (3) parasympathetic overreaction. Direct manipulation of these systems would test their relevance to the time course of the interference effect. Consider the possibility that exhaustion or inhibition of the adrenergic system mediates failure to escape. If this were so, artificially depleting the adrenergic system, e.g., with reserpine, should produce the interference effect. Preventing depletion of the adrenergic system during inescapable shock, e.g., with chlorpromazine, should prevent the interference effect. Promazine administered along with inescapable shocks prevents the interference effect (Brookshire, Littman, & Stewart, 1962). Direct measurement

of catecholamine levels throughout the time course is an alternative strategy. Similar manipulation and measurement of sympathetic and parasympathetic activity would assess their involvement in the interference effect.

There is no necessary incompatibility between such a physiological analysis and our psychological analysis of the interference effect. They might even be complementary. Our analysis holds that the dog's incentive to initiate behavior is undermined by his acquiring the expectation that responding does not control shock. However, incentive processes operate through a physiological medium. Therefore, physiological exhaustion might result from the acquisition of such an expectation. Analysis at both levels would contribute to our understanding of the interference effect.

Proactive inhibition.   The time course of the interference effect can be explained without recourse to an emotionally exhausted state. The dogs in our experiments arrived at the laboratory with a long but unknown history. Probably most of the dogs had experience with aversive events they could control, and such experience should proactively inhibit the failure to escape shock. Because proactive inhibition in both humans (Underwood, 1948) and animals (Maier & Gleitman, 1967) is known to increase in time, the dissipation of the interference effect can be explained. Twenty-four hours after inescapable shock in the harness, the PI is not strong enough to counteract the expectation that responding does not control shock. Forty-eight hours later, it is. Perseveration of the interference effect occurs because the added experience with inescapable shock makes the helplessness too strong to be counteracted by PI.

Prior experience might explain not only the time course but also the individual differences among the dogs in their responses to shock. We reported that 64% of the dogs receiving inescapable shock later failed to escape. Is it possible that the 36% who escaped normally were dogs with long histories of mastery over aversive events? We also reported that 6% of dogs who do not receive inescapable shock will nevertheless fail to escape. These might very well be dogs with a long history of inescapable aversive events. Developmental and controlled life-history experiments should answer these questions.

Retroactive inhibition.   This explanation also does not postulate emotional exhaustion. We returned the dog to his home cage after he received inescapable shock. What the dog does, and how often he does it, may retroactively inhibit what was learned in the harness. More inhibition might result from 48 hours of activity in the home cage than 24 hours. This hypothesis can be tested: simply keep the dog restrained in

the harness during the interval between inescapable shock and escape training.

Extinction and spontaneous recovery. The term "extinction" is ambiguously used. It may refer either to a procedure, an outcome, or an inferred process. We have already pointed out (p. 326) that the administration by the experimenter of inescapable shocks is not a conventional extinction procedure. It may, however, produce the same outcome as do normal extinction procedures and it may do so by the same underlying process. Either removing shocks completely or presenting shocks independently of the subject's responses might reduce the subject's incentive to initiate responses. One result of extinction procedures is spontaneous recovery. If extinction procedures and inescapable shocks induce the same process, we should see spontaneous recovery of response-initiation; and since recovery increases over time, more response-initiation should occur after a 48-hour rest than after a 24-hour rest. On the other hand, the usual course of spontaneous recovery for appetitively motivated behavior is over minutes, not hours or days. We know of no evidence on the course of spontaneous recovery for extinguished habits of an aversively motivated sort. It may be that this time course will turn out to be like the one we have observed following inescapable shocks.

Generality of the Interference Effect Across Situations, Responses, and Species

Failure to escape traumatic shock is highly maladaptive. It is important to know whether the behavior is peculiar to the dog and to the situations we have used. We think not. Many experiments conducted for a wide variety of other purposes have incidentally yielded the interference effect. Furthermore, many of these findings can be explained by the helplessness hypothesis.

Species. Deficits in escaping or avoiding shock after experience with inescapable shock has been shown in rats, cats, dogs, fish, and man. Using rats, at least 15 studies have shown an interference effect as a consequence of inescapable shock. For example, Mowrer (1940), Dinsmoor and Campbell (1956a, 1956b), and Dinsmoor (1958), all found that rats which had received inescapable shock were retarded in initiating their first bar-press–escape response and were slower to acquire the response once it had been emitted. Brown and Jacobs (1949), Mullin and Mogenson (1963), and Weiss and Conte (1966), all found that fear conditioning that is carried out with inescapable shocks results in escape and avoidance decrements. In addition, the more fear conditioning trials there are, the poorer

is the subsequent escape and avoidance performance. Finally, McAllister and McAllister (1962, 1963, 1965) showed a time course for a superficially similar interference effect when fear conditioning and "escape from fear training" took place in different apparatuses; the interference had dissipated after 24 hours.

Inescapable shocks imposed on weanling rats produce escape (and sometimes avoidance) decrements when the rats are adults (Brookshire, Littman, & Stewart, 1961; Levine, Chevalier, & Korchin, 1956; Denenberg & Bell, 1960; Denenberg, 1964). Finally, both Anderson and Nakamura (1964) and Hearst and Whelan (1963) gave inescapable shocks to rats which were performing poorly at wheel-turning avoidance. The treatment did not facilitate avoidance, but rather it produced many failures to escape.

McCulloch and Bruner (1939) found that pretreatment with inescapable shocks later resulted in poor discriminative escape from water when one of the alternative escape routes was punished by shock.

Using dogs (Carlson & Black, 1960) and using cats (Seward & Humphrey, 1967), experimenters have reported interference in escape resulting from previous inescapable shocks.

Behrend and Bitterman (1963) found that inescapable shocks retarded later Sidman avoidance learning by fish in an aquatic shuttle box. Pinckney (1967) found that fear conditioning retarded later shuttle box avoidance learning in goldfish. As did Mullin and Mogenson (1963), Pinckney found that the more fear-conditioning trials he gave, the poorer was the subsequent avoidance performance.

In human subjects, MacDonald (1946) found that inescapable shocks delivered to the finger retarded the later acquisition of finger-withdrawal avoidance.

Many of these studies show facilitation of avoidance performance following inescapable shocks, despite the fact that interference with escaping occurred. This finding is not a paradox for the helplessness hypothesis. Avoidance responding typically emerges only after the subject is escaping reliably. Our hypothesis maintains that inescapable shocks produce deficits in response-initiation and in the association between responding and shock termination. By the time the subject is reliably escaping shock, these deficits must be gone. Then there would be no reason to expect deficits in avoidance performance after escaping is reliable. As a matter of fact, subjects having difficulty in initiating escape behavior will experience more shock following each discriminative stimulus presentation. Conditioned fear of the stimulus should be more intense and therefore should facilitate avoidance.

Situations.   Prior inescapable shocks enhance the suppressive effects of punishment (Kurtz & Walters, 1962; Pearl, Walters, & Anderson, 1964).

If inescapable shocks result in a decrease in the initiation of active responding, then we would expect such a result, provided that the behavioral alternatives to the punished response do not consist of active responses.

Very well-learned escape and avoidance responses are enhanced by subsequent inescapable shock (Baum, 1965, 1966; Kelleher, Riddle, & Cook, 1963; Sidman, Herrstein, & Conrad, 1957; Waller & Waller, 1963). We have discussed the theoretical reason for this in connection with our "immunization" experiment with dogs. Clearly, the ordering of successes and failures in controlling trauma is a major determinant of subsequent escape and avoidance performance.

US's other than shocks can produce effects which may be analogous to failure to escape shock. For example, Richter (1957) produced sudden death in wild rats by forcibly immobilizing them in his hand. When such rats were put in a tank of water from which there was no escape, they gave up swimming after a few minutes and drowned. If, however, (1) Richter repeatedly held the rats in his hands and let them go, or (2) if he put the rats in the water and then took them out, then they swam for approximately 80 hours before dying. Richter attributed the sudden deaths in the first group to loss of hope. Other inescapable US's produce similar effects: death from inescapable tumbling (Anderson & Paden, 1966); passivity from defeat in fighting (Kahn, 1951); and disruption of food getting in very hungry rats as a consequence of inescapable shocks in infancy (Brookshire, Littman, & Stewart, 1961, Experiment 6). Inability to control trauma disrupts a wide range of adaptive behavior in many different species.

The Helplessness Concept Suggests New Lines of Research

Does helplessness occur in appetitive situations?   If a subject receives extensive experience in which rewarding brain stimulation is delivered independently of what it does, (1) will it later be retarded in initiating instrumental responses which procure reward? and (2) once it makes the response which procures reward, will it be retarded in associating response with reward?

Does helplessness generalize across different aversive US's?   Will prior experience with inescapable shocks retard the subsequent learning to escape a loud noise? It is conceivable that an animal that has learned that it cannot control one aversive event may not attempt to control another aversive event.

Does helplessness generalize from aversive to appetitive situations, and vice versa?   If a subject receives inescapable shocks, will it then fail

to initiate responses to procure food? If a subject receives food independently of its responses, will it then be poor at escaping shock? If such a result occurred, what mechanism might be involved? Could there be a generalized personality trait of helplessness which arises from long experience with a variety of events over which the subject has no control?

Are there avoidance sets?   We have shown that inescapable shocks received in one situation will interfere with subsequent escape from shock in another situation. Does the opposite occur? Suppose we train a dog to press a panel in order to avoid shock whenever a light flashes. Then would he learn more quickly to avoid shock by barrier jumping in a shuttle box whenever a tone occurs?

Are there analogues of the interference effect in Pavlovian conditioning? We have argued that the interference effect results from the subject's learning that response events are unrelated to reinforcement events. This not only inhibits response-initiation, but it also retards the association between other response events and reinforcements. If we conceive of a response event as a response-produced stimulus, then the relation is one of CS to US. This led Seligman (1968) to ask whether extended experience with a tone and shock, randomly interspersed, retards the association of a paired light with shock. He found this to be the case in rats. This may mean that an organism exposed to many, varied, unrelated events will have trouble perceiving that new related events are, indeed, related.

The converse may also occur. Seligman (1968) showed that experience with tone and shock pairings facilitated the association of later CS's and shock. This may mean that experience with related events may lower the threshold of conditionability. It may also be the case that such a subject will fail to perceive that events are unrelated when, indeed, they are unrelated. Finally, will a subject that has learned that stimulus events are unrelated, be retarded in the acquisition of an instrumental response because it will have difficulty perceiving the response–reinforcement relationship?

Does the helplessness hypothesis apply to shock onset and shock postponement?   In our experiments, not only did shock termination occur independently of the subject's behavior, but also shock onset and the time to the next shock were not under the subject's control. This raises some interesting questions. Would these subjects fail to initiate responses to postpone shock? If so, they would be poor at Sidman avoidance responding. Would these subjects be poor at initiating responses to prevent the onset of shock? Finally, can a subject be helpless with regard to one mode of controlling shock but not with others? The experimental test

of this is as follows: A dog is trained to press a panel in the harness to escape shock which is always signalled by a flashing light, but panel pressing does not change the probability of shock onset during the light–shock interval. Would the dog subsequently escape shock, but fail to avoid it in the shuttle box? Bloom and Campbell (1967) trained rats to avoid shock. They then removed the CS and allowed the rats only to escape. Finally, when the CS was replaced, the subjects made fewer avoidances than before the removal of the CS. Here is a case where removal of the subjects' control over shock onset leads to an avoidance decrement.

Can helplessness be brought under discriminative control? Suppose two dogs can press a panel in order to escape shock in the presence of a constantly present tone. However, when a light is on and the tone is absent, the shocks are inescapable. Now one dog is put in the shuttle box with the tone always present. The other dog is put in the shuttle box with the light present and tone absent. Will the tone dog fail to escape normally and the light dog succeed?

Helplessness and mastery as lasting traits. Our findings suggest a developmental study. Suppose we take one half of a litter of puppies and bring them up under conditions under which they are helpless to control all of the important events in their environment. Food and water come and are removed independently of the puppies' behavior. Long periods of deprivation are interspersed with short periods during which food is abundant. Aversive events come and go, with no relationship to behavior. The other puppies of the litter have the opposite experience. All of their food and water depend only on what they do or do not do. A repertory of specific, instrumental responses is strengthened by repeated response-reinforcement contingencies. How will the litter mates react to new situations which require: (1) the initiation of new responses and (2) the formation of new associations between responses and reinforcements? Will there be important differences between the groups?

Summary

Pavlovian fear conditioning controls escape and avoidance responding in two very different ways:

1. *The contingency between the CS and US gives the CS precise control over already established avoidance responding.* Here, the laws of Pavlovian salivary conditioning reveal themselves in several ways. The phenomena of excitation and differential inhibition, conditioned in-

hibition, inhibition of delay, and inhibition from backward conditioning all are seen in mediation of avoidance responding by conditioned fear. The fear-mediation postulate of two-process learning theory is well supported. In addition, other conditioning phenomena, such as inhibition from a cessation signal, generalization of fear across different US's, perseveration of excitation of fear derived from aversive US presentations, and differential excitation of fear by different US durations all are shown to control avoidance responding.

2. *The independence of shock termination and instrumental responding during Pavlovian fear conditioning subsequently disrupts the learning of escape and avoidance responding.* In conditioning, the subject cannot control shock. This contingency is shown to produce failure to escape shock when escape and avoidance training follow fear conditioning. This interference effect occurs following a wide variety of frequencies and durations of inescapable shocks. It also occurs independently of presence or absence of a signal and independently of the place of conditioning and escape training. In addition, the interference effect has wide generality across species, situations, and responses.

Escapable shocks do not produce the interference effect; moreover, escapable shocks immunize the subject against the interfering effects of inescapable shocks. Failure to escape shocks can be broken up by repeatedly forcing the subject to make the instrumental response which terminates shock.

The interference effect dissipates over time unless it is maintained by an intervening failure to escape shocks.

Several interpretations of all these findings are considered and discarded (adaptation to shock, sensitization by shock, emotional exhaustion, and a wide variety of "competing motor response" interpretations). Alternatively, we suggest a helplessness hypothesis which maintains (1) that inescapable shocks establish in the subject the expectation that responding is independent of shock termination, and (2) that this expectation lowers the subject's incentive to initiate responding in the presence of shock. The helplessness concept suggests many new experiments.

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