PROBABILITY OF SHOCK FOR R AND $\not{R}$ ON A TEMPORALLY-DEFINED SCHEDULE OF NEGATIVE REINFORCEMENT

By

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A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1975

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

December 31, 1974
date

Chairman of Examining Committee

January 3, 1975
date

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Abstract

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To evaluate the shock frequency reduction account of avoidance conditioning, behavior was examined along a continuum of negative reinforcement schedules, ranging from procedures in which responding is correlated with shock frequency reduction, to procedures in which responding is correlated with an increase in shock frequency. The results indicated that the amount of shock frequency reduction does not fully determine responding under the present schedules when shock frequency reduction is conceptualized as shock omission. Argument was made, however, that shock frequency reduction is best conceptualized as a special case of the operation of intruding shocks into an ongoing sequence of responses, and as such, fully determines avoidance responding. When shock frequency reduction is so conceived, avoidance disappears as a distinct schedule operation, and accordingly, as a special problem for behavior theory.

This dissertation is dedicated to my teachers, Drs. William N. Schoenfeld and Brett K. Cole whose concern, encouragement, and intellectual stimulation, made this work possible.

I would also like to thank Elaine Schulman, Jeff and Nancy Shamow, and Victor Schildkraut whose thoughtful actions greatly reduced the burden of the last few months.

Especial thanks are due to Roberta Simmons and Paul Tremont, who spent many weeks typing and agonizing over the final manuscript, solely from the motive of friendship.

CONTENTS

INTRODUCTION

In 1929, C. L. Hull published a paper titled "A Functional Interpretation of the Conditioned Reflex." In it he followed the theoretical predilections of his time in treating avoidable shock as a case of Pavlovian defense conditioning involving the principle of stimulus substitution. Unlike his predecessors, however, whose treatment of avoidable shock appeared to assume tacitly The Law of Exercise (e.g., Watson, 1916), Hull followed Pavlov's definition of extinction as the unaccompanied presentation of CS. He was, consequently, the first to treat the omission of an avoided noxious UCS as an extinction trial which weakened the avoidant CR.

This new conceptualization was expressed in what Hull called "the dilemma of the conditioned defense reaction:"

> "But in case the unconditioned stimulus fails to impinge upon the organism, there will be no reinforcement of the conditioned tendency which means (one would expect) that experimental extinction will set in at once. This will rapidly render the conditioned reflex impotent which, in turn, will expose the organism to the original injury. This will initiate a second cycle substantially like the first which will be followed by another and another indefinitely, a series of successful escapes [i.e., avoidances] always alternating with a series of injuries."

While Hull's treatment of avoidable shock proceeded from Pavlov's concept of extinction, Hull was, in a sense, extending this concept beyond previous boundaries. Pavlov (1927) had expressed uncertainty concerning the theoretical status of isolated CS presentations intermixed with a series of CS-UCS pairings (as in avoidable shock) as distinguished from the case where they followed a series of CS-UCS pairings. This uncertainty stemmed from Pavlov's view that inhibition was the sine qua non of extinction, and from his failure to find evidence for inhibition in an experiment in which the UCS was only occasionally paired with CS presentation. Thus, it was demonstrated that salivary conditioning failed to occur after 240 trials when the UCS was only presented on every fourth trial. Afterward, however, inhibitory effects could not be discerned when the ineffective CS was presented before a pre-established CS, since no reduction in the strength of its CR was observed. Also, when the ineffective CS was paired with the UCS on every trial, conditioning developed at a "maximal" rate.

By treating isolated CS presentations intermixed with CS-UCS pairings as extinction trials, Hull's analysis implied that the two types of shock procedure (avoidable and unavoidable shock) which his predecessors had treated as indistinguishable had different behavioral consequences. By his analysis, the former involved a com-

bination of reinforcement and extinction, while the latter involved reinforcement alone. Interestingly, Hull himself did not make this distinction in the explicit terms used here. While his predecessors may not actually have understood the need for continued applications of the UCS once the CR was acquired, Hull's omission was probably due to two things: first the particular arrangements of Pavlov's defensive conditioning paradigm in which the conditioned response (salivation) attenuated the impact of the unconditioned stimulus (acid); and, second, to his own emphasis on the functional significance of the conditioned reflex, which led him to slight the unavoidable shock case. It remained for Schlosberg to draw out and make explicit the full implications of Hull's analysis.

Starting in 1934, Schlosberg published a series of papers (Schlosberg, 1934, 1936, 1937a) which included a distinction as well as an experimental comparison of conditioning paradigms employing avoidable and unavoidable shock. Schlosberg believed "...that the [Pavlovian] conditioned response ... is only one type of learning, no simpler than the other types traditionally considered under the headings of [Thorndikian] 'trial and error,' 'association,' etc... probably no one of them is more fundamental than the others." In interpreting the results of the avoidable versus unavoidable shock experiment, Schlosberg reasoned that if Hull was correct (that response-

produced shock omission was an instance of Pavlovian extinction) then two experimental results might be predicted: First, the CR, under the avoidable shock procedure, should manifest a waxing and waning of strength, as Hull thought; and, second, that the avoidable shock procedure should lead to poorer conditioning than the unavoidable shock procedure because of fewer UCS presentations. If, however, the superiority of avoidable shock was demonstrated, then response-produced shock omission could not be construed as Pavlovian extinction, but instead, must be considered reinforcement, conforming to Thorndike's law of effect. Under the latter interpretation, the "success" of the avoidant CR in preventing the noxious UCS saves it from failing under Pavlovian extinction. The "success" of the CR is determined by "...the effect the response has on the unconditioned stimulus... [and] ... the nature of the unconditioned stimulus. Thus, a conditioned response will be considered successful if it prevents or terminates a 'nociceptive' unconditioned stimulus, or if, on the other hand, it leads to, or increases, a 'beneceptive' unconditioned stimulus. Conditioned responses will be 'unsuccessful' in the reverse cases... In some experimental situations... the conditioned response cannot be considered either successful or unsuccessful, since it cannot affect the unconditioned stimulus." (Schlosberg, 1937b).

By this analysis, Schlosberg raised the question which came to preoccupy workers in avoidance theory

during the decade of the thirties: is the avoidant CR an instance of Pavlovian extinction, via shock omission, or are Pavlov's laws abrogated when the additional factor of "success" is involved? The principal experimental design indicated by this question was the comparison of findings with avoidable and unavoidable procedures. In Schlosberg's own attack on this question electric shock was delivered through surface electrodes to the tail or foreleg of physically restrained rats. In general, his design used animals divided into two groups: one group always received an electric shock of fixed duration following the onset of a stimulus (except on those occasions when conditioning was probed by the use of CS test trials), while the other group could avoid or terminate the shock by moving the tail or leg, depending on which member received the shock. The results were inconclusive; conditioning was about the same under the avoidable and unavoidable shock conditions. Generally, the shocked member conditioned poorly (respiratory changes showed best conditioning) with the consequence that the strengthening or weakening effects of shock omission were difficult to ascertain since the animals under the avoidable shock condition rarely avoided the shock, though they consistently terminated it after its onset. In one case (Schlosberg, 1936), however, Hull's deduction from the Pavlovian model was confirmed. A rat from the unavoidable shock group whose leg flexions consistently anticipated shock was switched to the avoidable shock condition. A

cyclic series of disappearances and reappearances of the CR, following shock avoidance and presentation, respectively, could be observed to be superimposed on a gradual decline in CR frequency. Thus, Schlosberg's work on the problem, if anything, lent support to the Pavlovian account of avoidable shock: in his words, they suggested "...that a withdrawal that prevents the shock leads to 'experimental extinction' of the conditioned response, instead of to a 'stamping in' of the 'successful' response."

From other quarters, however, a different picture emerged. Within a year of the initiation of Schlosberg's studies, Hunter (1935) also distinguished and experimentally compared avoidable and unavoidable shock. Where Schlosberg's interest in this distinction was mainly in the relative merits of a Pavlovian or Thorndikian account of avoidable shock, Hunter accepted the Pavlovian account and approached the avoidable versus unavoidable shock distinction through a concern with punishment, that is, the disruptive effects on a conditioned reflex of a closely following noxious UCS.

In one of Hunter's experiments, rats were trained in an eight-sided, four compartment box, where an electric shock was presented two seconds after the onset of a buzzer unless they ran to a different compartment. After training, one group was extinguished in the usual way, the buzzer being repeatedly presented alone without shock; the other group was shocked if they ran in response to the

buzzer within two seconds of its onset, but were not shocked if they sat still. Extinction training continued until the rats failed to respond to the buzzer on five successive presentations. The results of this experiment were clear: the group for which no further shock was scheduled, regardless of their response, took an average of 63.6 trials to reach extinction, while the group which was shocked for responding took an average of 6.8 trials. Since unavoidable shock appeared to Hunter to be analogous to the "shock extinction" procedure - both allowed shock to occur immediately after a response - Hunter reasoned "... that conditioning time will be seriously increased by inhibitory factors if shock always and invariably follows the conditioned stimulus irrespective of whether or not the conditioned response has been made." To test this prediction, Hunter trained another group of rats as described above, except that shock was always presented two seconds following the onset of the buzzer. Of the thirty rats used in this experiment, only four reached the criterion of 10 successive runs to the buzzer. Only five of a group of 43 rats previously trained with avoidable shock failed to reach the same criterion.

Subsequent workers, taking their lead from Schlosberg, treated Hunter's finding as a refutation of the Pavlovian account of avoidable shock, that is, the weakening of the avoidant CR through extinction, to be expected by the Pavlovian model, could not be discerned when the

acquisition of the CR under avoidable and unavoidable shock was compared. Yet Hunter saw "... no reason for doubting that the rat's behavior in the present instance should be classed as a [Pavlovian] conditioned response...." This divergence appears to have arisen from Hunter's implicit conclusion that electric shock, when it followed a CR, functioned as a "punishing" stimulus which exceeded in its weakening effects that which derived from isolated CS presentation. This idea left intact the Pavlovian account of avoidable shock, since it could concede that extinction weakened the avoidant CR, while claiming that the extinction was overbalanced, and consequently masked, by the more debilitating effects of punishment under the unavoidable shock procedure.

The Pavlovian alternative to a Thorndikian account of avoidable shock was not destined to have much impact. The cause of its neglect appeared to be twofold. Conceptually, while the concept of punishment naturally conformed to, and historically proceeded from, the implicit hedonism of a Thorndikian analysis, it appeared to be inconsistent with the associationism of Pavlov. Empirically, and notwithstanding Hunter's demonstration, there remained the fully documented behavioral reality of Pavlovian defense conditioning, which appeared to belie the punishing effects of a noxious UCS. Whatever the reason, the exclusion of punishment from a Pavlovian analysis was illustrated during the 1930s by Hilgard's (1937) dichotomies

between reinforcement and extinction (Pavlovian conditioning), and between reward and punishment (Thorndikian learning), and by Skinner's (1935) statement that "In type I [later to be called operant conditioning] stimuli may... produce an increase or decrease when used as reinforcement. The distinction cannot be made in Type II [Pavlovian conditioning] ...where its strength only increases..."

The other experiment of historical importance for the empirical resolution of the avoidable versus unavoidable shock question was reported by Culler (1938) and by Brogden, Lipman, and Culler (1938). Eight guinea pigs were trained in a running wheel; four of the animals could avoid a shock, which occurred two seconds after onset of a tone, by turning the wheel one inch or more in the two second interval; the other four animals received the shock whether they ran or not. The acquisition curves - mean percentage of trials on which CR occurred plotted against daily blocks of 25 trials - showed that both groups initially progressed at the same rate. By the fourth day, however, the groups diverged, with the avoidable shock group quickly achieving the conditioning criterion (25 CRs in a daily block of 25 trials), while the unavoidable shock group never progressed beyond a maximum of 50 per cent and started to decline after the thirteenth day.

With these and the Hunter data in hand, Schlosberg in 1937 (Schlosberg, 1937b) published an analysis in which he followed the logic of the avoidable versus unavoidable shock experiment to its conclusion. Response-produced

shock omission, via "success", was given casual status with regard to the strengthening of the avoidant CR.

> "...the original withdrawal is a result of simple conditioning, but it is fixated by its success in avoiding the shock. That this fixation occurs is demonstrated by Culler's and Hunter's reports that learning develops more rapidly under the avoidable shock situation than it does under the fixed shock of more typical conditioning situations. Thus, 'effect' seems to mask or counterbalance the extinguishing effect of the omitted reinforcements, to such an extent that the response is actually fixated more rapidly than it is under regular reinforcement."

However, in thus formalizing "success" as a valid explanatory category, Schlosberg was forced to come to grips with the apparent contradiction between his own laboratory findings and those of Hunter, and Culler. It will be recalled that, in his experimental papers, Schlosberg had described his results as generally demonstrating no difference between the avoidable and unavoidable shock groups, but that extinction had occurred when a rat was switched from the unavoidable to the avoidable shock procedure. Thus, it appeared to him that "success" must be conjoined with a supplementary principle in order to account for avoidance conditioning. To this end, Schlosberg divided behavior into two classes. One class subsumed responses which he termed diffuse, tonic, or preparatory; the other subsumed precise or adaptive responses. Specifically, with electric shock as the conditioning stimulus, precise responses were "...those...usually of skeletal muscle, that would remove

the member from the locus of the shock..." (such as the flexion response), while diffuse responses were "...those reactions of muscle and gland that result from the shock but are not specific to the shocked area [such as] changes in the breathing rhythm, pulse rhythm, and, electrical skin resistance..." Thorndike's law of effect had as its principal area of application the first class, while Pavlov's laws of conditioning chiefly applied to the second. The discrepancy between Schlosberg's results, and those of Hunter, and Culler, was thus disposed of by the argument that the responses studied by Hunter, and by Brogden-Lipman-Culler, were precise and could consequently be strengthened by "success" when shock was avoided, while the responses studied in his (Schlosberg's) experiments were diffuse, and were consequently weakened through extinction when shock was omitted.

There was still another sense in which "success", via shock avoidance, could not carry the full explanatory burden of the avoidable shock procedure. While, by Schlosberg's analysis, "success" (in conjunction with supplementary principles) accounted for the strengthening of the avoidant CR, it could give no account of its inception, since the avoidant CR had first to occur before its "success" could be implemented. While this idea was implicit in Schlosberg's account, it was made explicit by Mowrer and Lamoreaux (1942):

> "...in both instrumental and classical conditioning, the procedure is exactly the same (uniform paired presentation of the conditioned and unconditioned stimulus) up to the point that the first conditioned response occurs... Only with the advent of a conditioned response do the procedures and the underlying mechanisms become differentiated..."

Thus, with "success" as its modus operandi, a theoretically adequate description of the avoidable shock procedure required the positing of two experimental operations: shock presentation, and response-produced shock omission. These two operations, in turn, appeared to demand two different underlying mechanisms for an explanation of avoidance responding. Accordingly, Schlosberg ascribed the behavioral effects of the avoidable shock procedure to a combination of Thorndike's law of effect, and Pavlov's laws of conditioning, the latter being necessary to account for the initial appearance of the avoidant CR. Thus, by 1937, the outline of a two-factor theory of avoidance conditioning had emerged. Henceforth, with a few exceptions, and without always resorting to Pavlov's laws of conditioning to fill the breach, the theory of avoidance conditioning would be fractionalized "...as if there were one mechanism for bringing the conditioned response into existence, another mechanism for perpetuating it if it is 'successful', and yet another mechanism for suppressing it if it is a failure." (Mowrer and Lamoreaux, 1942). This limitation did not, of course, apply to shock presentation, and,

consequently, did not prevent the Pavlovian model from giving an account of the acquisition and strengthening of the avoidant CR, in toto. Here, empirical considerations prevailed; "success" appeared necessary to distinguish the stable avoidant CR from Pavlovian extinction, and, consequently, became a permanent fixture in what had previously been an exclusive Pavlovian domain.

"Success", during the decade of the thirties, was also encroaching upon behavior theory through a different route, and this development was also destined to leave its imprint on avoidance theory. Starting in the 1930's, behavior theory became concerned with the observation that the CR usually did not fully resemble, and in some cases seemed very different from, the UCR, with regard to amplitude, latency, and form. While some of these differences did not appear critical - for example, a segment of the UCR, which depended on the animal's manipulation of the UCS, would not be expected to occur to the CS alone - others appeared to contravene a stimulus substitution interpretation. Such discrepancies became associated, for many theorists, with the "explanatory" notions of "success", "satisfaction", or "adaptiveness", probably because CR-UCR disparity appeared consonent with those experimental arrangements (and, consequently, the associated modes of explanation) originating from Thorndike's puzzle-box experiments, where, for example, the response to food was different from the response of opening a latch. This development was chronicled by both Hilgard, and by Guthrie:

> "The restricted freedom of the responses which were subjected to measurement in Pavlov's experiments limited the contradictions to be expected between his results and substitution theories... In experiments allowing more freedom, and those in which more samples of the total reaction are recorded, more discrepancies appear between conditioned and unconditioned behavior. When these discrepancies and variabilities become pronounced, experimenters tend to fall upon adaptive-

> ness as a basis for explanation." (Hilgard, 1936).
>
> "One important reason why so many experimenters in the field of conditioning (which deals directly with association and not with goals) have been led to desert an objective description for a more loose and easy description in terms of success is that on so many occasions the response to the new signal has not been the movement supposedly associated with the signal but something else, something which may often be loosely called adaptive." (Guthrie, 1940).

For avoidance theory, this theme manifested itself most clearly in the work of Mowrer and Lamoreaux (1946). These workers argued for the operation of the law of effect, through fear reduction, on the basis of the demonstration that rats acquired an avoidance response, though they were required (from the beginning of the experiment) to respond differentially to signal and shock in order to avoid and terminate shock, respectively. This experiment, however, and the ideas associated with it, were foreshadowed by the work of Warner, and of Culler, in the 1930's.

Warner (1932) noted, and devised experimental arrangements for the detection of, CR-UCR disparities. In one of his experiments, rats could avoid or terminate a shock, presented one second after the initiation of a sound, by either jumping over, or going under, a fence. Of the eleven animals used in this experiment, four responded differentially to the sound and the shock, hastily scamp-

pering beneath the fence, in response to the shock, and making smooth, deliberate crossings over the fence, in response to the sound.

While Warner's procedures were designed to enhance the likelihood of detecting CR-UCR disparity, Culler (1938) took the next step of direct manipulation, by changing the type, or locus of application, of the UCS, so that the new UCR no longer corresponded to a previously conditioned CR. For example, in one of a series of parallel experiments, dogs could avoid a shock to the right forepaw, which occurred two seconds after the initiation of a tone, by flexing the right foreleg. After the conditioning criterion was attained, a light was presented concomitantly with the tone, but now shock was presented to the left thorax when the flexion response was omitted. Under the condition of thoracic shock, the forepaw response was maintained, and came to be elicited by the light alone, even though the thoracic shock did not elicit the foreleg response, as had forepaw shock. Furthermore, while continuing to present the thoracic shock when the foreleg response was omitted, but without reverting to forepaw shock, the foreleg response came to be elicited by a fifth order stimulus, with every indication that it would be indefinitely maintained.

For subsequent theorists, Culler's experiments came to reinforce the conclusions drawn from the avoidable versus unavoidable shock experiments (with which

they temporally coincided), namely, that Thorndikian learning, rather than Pavlovian conditioning, was the archetype of the avoidable shock procedure. Culler's experiments appeared to demonstrate that avoidable shock could not be construed as a Pavlovian UCS, since the initial CR was maintained, in contradiction to the principle of stimulus substitution, after CR-UCR disparity was introduced. Yet, despite their apparent concurrence on the central role of "success", the lines of research initiated by Schlosberg, and by Culler, entailed diametrical assumptions concerning CR identification rules. This incongruency, though unnoted at the time, proved to be important for avoidance theory.

A fundamental assumption made by Schlosberg, in using the avoidable versus unavoidable shock experiments to derive the causal efficacy of "success", was that a segment of behavior could be regarded as a CR only if it topographically resembled the UCR. In accordance with this assumption, the Hunter and the Brogden-Lipman-Culler experiments were interpreted as showing that the avoidable shock group conditioned better than the unavoidable shock group, since the behavior which emerged in the former, resembled the UCR, while the behavior which emerged in the latter, did not.

This assumption was intertwined with Schlosberg's notions concerning the inception and subsequent course of development of the CR. It will be recalled that

the incipient CR emerged by way of Pavlovian conditioning, and, consequently, resembled the UCR. Subsequent development involved the augmentation of the CR along the dimensions of latency, amplitude, and frequency, leaving intact its "topographical" correspondence to the UCR.

While this mode of thought - a carryover of the Thorndikian metaphor of "stamping in" - suited Schlosberg's emphasis on CR frequency as the measure of goodness of conditioning, it was not in keeping with considerations stemming from CR-UCR disparity, for here, perforce, the topographical evolution of the CR was emphasized. To quote Culler:

> "...CR (1) begins as a copy of UR and then (2) grows into something different... Normally...CR differentiates into a specific preparation for the oncoming US. This essentially preparatvie character of CR appears on every hand. It relaxes or contracts the muscle, according to which activity is needed to bring it into a state of medial tonus for reacting to US."

Here, as with Schlosberg, the incipient CR corresponds to the UCR. However, instead of being stamped in by "success", the CR comes to be shaped by the adaptational exigencies of the conditioning procedure, so that in its terminal evolution, the CR solves - insofar as the experimental arrangements permit - the problem posed by UCS presentation. However, though originating from the consideration of CR-UCR disparity, Culler's position was still congruent with instances of CR-UCR correspondence, for im-

plicit in Culler's emphasis on the preparatory or adaptive function of the CR, was the expectation that the incipient CR, instead of evolving, would be maintained as a copy of the UCR, if as such it adequately prepared the organism for the oncoming UCS.

Culler's account of the dynamics of CR change entailed, as did Schlosberg's, the choice of a CR identification rule. Accordingly, and in contrast to Schlosberg's account, a segment of behavior was given CR status by dint of its adaptive function, regardless of its degree of correspondence to the UCR. The difference between the CR identification rules used by Schlosberg and by Culler was reflected in the Brogden-Lipman-Culler account of their avoidable versus unavoidable shock experiment:

> "One group finds a solution by turning the cage, the other faced with unavoidable shock, places and tenses the trunk and limbs as to minimize its effects. The functional significance of CR is crucial in deciding what form it shall assume; and this significance is itself altered when the incentive is differentially applied."

Here, with running as the ostensible UCR, Brogden, Lipman and Culler, treated the behavior of the unavoidable shock group (tensing) as equal to the behavior of the avoidable shock group (running); both were treated as CR's, sui juris. This, of course, was in opposition to Schlosberg's treatment, in which running, alone, was given CR status. Thus, Brogden, Lipman and Culler's interpretation of their avoidable versus unavoidable shock experi-

ment was inconsonant with the argument by which Schlosberg had derived the reinforcing efficacy of shock avoidance. By the former, statements pertaining to the superiority of avoidable shock, rather than referring to the absence of extinction when shock is avoided, merely indicate (to paraphrase Brogden, 1939) the CR which coincides with the interest and aim of the experimenter.

This incongruity passed unnoted during the decade of the 30's. Perhaps this was due to a conviction that CR-UCR disparity, though inconsonant with the CR identification rule which was used by Schlosberg to derive the reinforcing efficacy of shock avoidance, demonstrated (without need of further support) that "success" was the modus operandi of the avoidable shock procedure. For whatever reason, the central role of "success", in providing an account of the avoidant CR, remained intact, and became, in turn, the seminal source from which subsequent theorizing proceeded.

Thus, by the end of the 1930's, a consensus of opinion existed to the effect that "success" was essential to any theoretical conceptualization of the avoidable shock procedure. Accordingly, theoretical effort came to concentrate on elucidating the mechanism by which "success" made its impact. In this regard, Schlosberg's notion that the avoidant CR "...is fixated by its success in avoiding the shock", appeared to suit the modes of explanation deriving from expectancy theory, for it appeared (to quote

Hilgard and Marquis, 1940) that "...the absence of shock can be rewarding only if some sort of expectation of the shock has been established in the subject." Yet, for those theorists who emphasized the role of R-S^R contiguity, to the exclusion of all other principles of reinforcement, the absence of reinforcement in the manifestation of S^R presentation, or S^{-R} termination, merely served to raise the specter of an unreinforced avoidant CR. Accordingly, theoretical effort was then directed toward the events, contiguous with the avoidant CR, which could be postulated or construed as reinforcing. This effort was pioneered by O. Hobart Mowrer, to whose work we now turn.

Mowrer's entry into avoidance theory, and the theoretical notions that he applied thereto, may be traced to his attempt, in 1938, to save "...the universality of the law of effect as a theory of the learning process..." from the exception of Pavlovian defense conditioning:

> "In the case of these so-called conditioned defense reactions, the occurrence of a painful state of affairs appears not only to strengthen but actually to establish this new stimulus-response relationship... In the light of this type of observation, many investigators reject the law of effect and adhere to the law of exercise or some variation of it, despite the evidence which can be mustered against it."

By 1938, Mowrer had adopted - from Muenzinger and Fletcher (1936) - a formulation of the law of effect which identified reinforcement with "drive" reduction. In applying this formulation to Pavlovian defense conditioning, Mowrer noted that the reduction of "biological drives" could not serve as reinforcement under Pavlovian defense conditioning when electric shock of brief duration was used as the noxious UCS, for "...escape from stimulation of such brief duration [could] scarcely be regarded as meaningful."

Accordingly, Mowrer postulated the existence of an "expectancy", or "preparatory set", for recurrent presentations of a noxious UCS. This "expectancy" or "preparatory set", is composed of a state of heightened "tension", and as such, serves as a source of reducible drive under Pavlovian defense conditioning, for:

> "...one can think of escape from tension as providing no less appropriate conditions for the operation of the law of effect than does escape from hunger, escape from protracted electric shock, or escape from any other motivating stimulation."

Specifically, following the onset of the CS, anticipatory tension builds up, until it reaches a maximum at the time of presentation of the noxious UCS, following which tension is reduced by the elicitation of the UCR, ostensibly because "... the [noxious UCS] elicits those reactions for which the pre-existing tension or preparatory set is specifically appropriate." By this mechanism, the UCR comes to be elicited by the CS; for the sequence, CS-UCR, is followed by tension reduction, with the consequence that the connection between CS and UCR is strengthened by reinforcement.

Here it may appear that Mowrer's use of the expectancy concept was inconsonant with his expressed intention of explaining Pavlovian defense conditioning exclusively by the law of effect. Yet, in fact, Mowrer's manner of application of the expectancy concept remained within the modes of explanation countenanced by the law of effect, and bore (appearances notwithstanding) only superficial resemblance to the tenets of expectancy theory, for under expectancy theory, reinforcement is mediated through the <u>confirmation</u> of an expectancy, not through the <u>termination</u> of an expectancy, as drive.

Perhaps it is with regard to the foregoing distinction that Mowrer's use of the term "anxiety" (or "fear") should be understood. Starting in 1939, Mowrer exclusively identified expectancy with anxiety (or fear) whenever expectancy referred to the occurrence of S^{-R}. It appears possible that the designation of anxiety (or fear) - though ostensibly prompted by Freud's psychoanalytic writings - was primarily motivated by Mowrer's desire to emphasize drive as the modus operandi by which expectancy mediated reinforcement, and to mute the implication of cogitation carried by the expectancy designation per se. For whatever reason, the designation of anxiety (or fear) became increasingly prominent in Mowrer's subsequent writings, and finally replaced, altogether, its prototypic counterpart.

As we have seen, Mowrer's exclusive commitment to the law of effect - specifically, to the notion that reinforcement is mediated through drive reduction - had led him to postulate the existence of expectancy (later to be called anxiety or fear) as a source of reducible drive to allow for the possibility of reinforcement - as stipulated by the law of effect - under Pavlovian defense conditioning. Now in 1942, Mowrer applied this mode of thought to the analysis of avoidance conditioning. As Mowrer noted:

> "...one might say that it is rewarding not to receive the noxious stimulus which the conditioned stimulus presages and the conditioned response averts. But

> such a statement is obviously vague and incomplete. In the final analysis, reward appears always to involve the elimination (or reduction) of actual stimulation, i.e., a state of discomfort, or motivation. Therefore, not getting something can hardly, in and of itself, qualify as rewarding. Not getting 'punished', or 'injured', is rewarding only if punishment is expected, i.e., only if the subject is anxious or fearful, and if this expectation in some way gets reduced."

By this analysis, the avoidant R is reinforced through the termination of anxiety or fear, not by the avoidance of S^{-R} *per se*, and thus, by the foregoing mechanism of reinforcement, avoidance becomes a species of escape conditioning. However, implicit in Mowrer's analysis was the notion that the avoidance of S^{-R} does play a role in the maintenance of the avoidant R, albeit a subsidiary one. Specifically, if R did not avoid S^{-R}, that is, if R was repeatedly followed by S^{-R}, its concomitant proprioceptive stimuli would come to elicit anxiety or fear, with the consequence that "...the subject... [would be] ... motivated not to engage in... [R] ...since not doing so [would be] rewarded through anxiety-reduction." Thus S^{-R} avoidance serves to protect the avoidant R from response competition, and by so doing, allows for the maintenance of the avoidant R through anxiety or fear reduction.

In order to test the foregoing account, Mowrer postulated that under avoidance conditioning, "...fear, as an 'emotional' reaction, is aroused by [the condi-

tioned stimulus] ...", and consequently,"...is likely to diminish with the termination of the [conditioned stimulus] ." From these postulations, Mowrer reasoned that if the avoidant R is reinforced through fear reduction, then - in accordance with the "temporal gradient of reinforcement" - better avoidance conditioning should occur if the CR (and thus anxiety) is made to terminate with the avoidant R, than if it terminates appreciably after, or before, the avoidant R. To test this prediction, Mowrer ran three groups of rats on an avoidance procedure, where the response of crossing over to the opposite half of a shuttle-box prevented (or terminated) an electric shock which otherwise occurred 5 seconds after the initiation of a buzzer (the CS). For group I, the buzzer continued for a fixed duration of one second. Here, since most of the crossing responses had a latency of greater than one second, the avoidant R usually followed buzzer termination. For groups 2 and 3, the termination of the buzzer was conditional on the occurrence of the crossing response. For the former, the buzzer terminated immediately with the crossing response, while for the latter, the buzzer terminated after a delay of five seconds. As Mowrer had predicted, avoidance conditioning was superior - as ascertained by the incidence of avoidant Rs - when the CS terminated with the avoidant R, than when CS termination preceded, or appreciably followed, the avoidant R (with no significant difference between the latter two procedures). Yet,

though confirming his account of the reinforcement of the avoidant R, Mowrer's experiment "...raise[d] an incidental problem of very considerable interest", for, notwithstanding the foregoing result, a substantial amount of conditioning had been evinced when CS termination preceded the avoidant R, and consequently, the problem arose as to how (under this procedure) the avoidant R could have been reinforced by fear reduction when "...there was no change in the external stimulus situation when the right response [the avoidant R] had been made..."

Here, Mowrer again resorted to response produced (proprioceptive) stimuli - as he had done in construing the role of S^{-R} avoidance in the maintenance of the avoidant R - and argued:

> "Since the stimulus trace of the buzzer and the stimulus trace of the avoidant response would never precede the shock, then this combination would mean safety, as opposed to the danger implied by the buzzer trace alone...Thus... an animal could eventually learn, on the basis of internal cues, to feel rewarded (freed from anxiety) when it had behaved 'properly'."

Yet, this allusion to the possible role of response produced stimuli was merely a footnote in Mowrer's account, and emphasis continued to be placed on CS termination as the conduit for fear reduction. It remained for subsequent theorists to draw out the implications of Mowrer's

analysis, and, thus to initiate the study of avoidance procedures without an exteroceptive CS; a development which proved to have a profound effect on the subsequent course of avoidance theory.

A difficulty encountered by Mowrer in his attempt to explain avoidance conditioning exclusively by the law of effect was the need to elucidate the mechanism whereby fear is learned. Mowrer could not resort to the natural solution of Pavlovian conditioning, or, for that matter, to any other learning principle, exclusive of the law of effect.

In his attempt to advance a law of effect account of fear acquisition, Mowrer had, in 1942, employed the notion of "parasitic" reinforcement. In accordance with this notion, fear comes to be elicited by a previously neutral CS under an avoidance conditioning procedure, by dint of the fact that the sequence, CS-fear (the latter being elicited by S^{-R}), is followed by the termination of S^{-R}, and is thus reinforced by drive reduction. As with Pavlovian conditioning, the solution proffered by "parasitic" reinforcement, for the problem of fear-learning, stipulates the recurrent pairing of a neutral stimulus with a fear-eliciting UCS, but differs from the former by placing emphasis on the temporal coincidence of a neutral stimulus with UCS termination, rather than with the onset of the UCS.

By 1947, however, Mowrer had concluded that

the notion that "...living organisms [are] so constructed that they can learn to fear traumatic stimulation only when that stimulation is 'all over'... [is] ...contrary to intuitive common sense and to biological considerations." Instead (Mowrer argued) it is more reasonable to conclude that animals are "...constructed in such a way that fear-learning is produced by the coincidence of a danger signal and the impact of the trauma..."

For this and other reasons, Mowrer repudiated his long-standing commitment to the law of effect as the universal principle of learning. With regard to avoidance conditioning, the avoidant *R* was reinforced, as before, by way of fear reduction, and thus in accordance with the law of effect. Now, however, fear came to be elicited by a previously neutral CS through the medium of Pavlovian conditioning:

> "We know that in certain instances of learning what happens when a drive is terminated and satisfaction is experienced is crucially important; but it now appears equally clear that certain other instances of learning depend upon the onset, rather than upon the termination, of a drive... for the present it seems necessary to assume that there are two basic learning processes: the process whereby the solutions to problem[s], i.e., ordinary 'habits', are acquired [the law of effect] ; and the process whereby emotional learning [Pavlovian conditioning] takes place."

This development was ironic, for it will be

recalled that the elimination of Pavlovian conditioning as an independent category of learning was the casus belli which had prompted the notion of expectancy as drive - the prototype of the fear concept. Indeed, this was not the only irony engendered by the consideration of fear-learning, and it is to this point which we now turn.

It will be recalled that the Pavlovian account of avoidance conditioning entailed the notion that S^{-R} presentation reinforces the avoidant R, and consequently, that the occurrence of the avoidant R, by preventing S^{-R}, sets the stage for its own extinction. The finding that animals conditioned better under the avoidable than under the unavoidable shock procedure was interpreted as showing that extinction did not occur under the former, and this constituted the major reason for the abandonment of the Pavlovian account of avoidance conditioning.

Ironically, Mowrer's notion that the avoidant R is reinforced by fear reduction, though recommended on the ground that it explained how "... a conditioned response may be perpetuated, independently of [S^{-R} presentation] " (Mowrer and Lamoreaux, 1942), also required that S^{-R} be presented for the avoidant R to be maintained. Reinforcement of the avoidant R, through fear reduction, necessitated that fear be present, and whether fear conditioning was construed as parasitic reinforcement, or as classical conditioning, the presentation of S^{-R} was necessary for the maintenance of the fear CR.

Thus, Mowrer's account of avoidance conditioning appeared to entail the same notion which had led to the abandonment of the Pavlovian account - that the presentation of S^{-R} was necessary for the maintenance of the avoidant R. Here, however, the superiority of the avoidable over the unavoidable shock procedure did not appear to

be critical, for it will be recalled that Mowrer had imputed a subsidiary role to S^{-R} avoidance - it served to protect the avoidant R from response competition. Consequently, the argument could be made that animals under the avoidable shock procedure condition better than those under the unavoidable shock procedure because the extinction of the fear CR, when shock is avoided, is overbalanced by the conditioning of responses which are incompatible with the avoidant R, when shock is presented.

With regard to the foregoing, however, a source of embarrassment for Mowrer's formulation was that the experimental literature contained a number of demonstrations showing that animals could make a large number of consecutive avoidant Rs without the occurrence of intervening S^{-R}s. For example, Solomon and Wynne, in 1954, reported that "...in return for a few intense shocks during acquisition of avoidance, dogs gave back as many as 650 avoidances without showing any signs of extinction." Since, by Mowrer's formulation, the avoidant R would begin to extinguish immediately after the fear CR had extinguished, and since the avoidant R, by preventing S^{-R}, sets the stage for the extinction of the fear CR, it appeared necessary to postulate that the fear CR is extremely resistant to extinction, and even, under certain experimental arrangements, completely inextinguishable.

Probably, for this reason, Mowrer, in 1942, noted that his fear reduction account of avoidance con-

ditioning involved the assumption:

> "...that fear, as a form of motivation which is itself due to a conditioned visceral reaction...is easier to establish and harder to extinguish than are conditioned skeletal responses."

and later, in 1954, Solomon and Wynne - prompted by what appeared to them to be inextinguishable avoidance behavior when high intensity shock was used as the S^{-R} - suggested that:

> "In the case of intense anxiety, established with the support of an initial intense pain-fear reaction [to the UCS] ...the classically conditioned [fear] responses have become incapable of complete extinction."

This attempt to reduce the dependency of conditioned fear on S^{-R} presentation, and thus to make the fear reduction account of avoidance conditioning consonant with the fact that a large number of avoidant Rs may occur without an intervening S^{-R}, did not appear to hold much promise. When responses which are taken to be indices of fear (e.g., crouching, urinating, defecation, heart rate change, and CER) are measured concurrently with avoidance responding, well maintained avoidance behavior often occurs in the absence of fear symptoms (Rescorla and Solomon, 1967). Thus, it appeared, irrespective of the degree of resistance to extinction imputed to fear, that avoidant Rs could be perpetuated long after fear had extinguished,

that is, long after reinforcement via fear reduction had been eliminated.

In an attempt to save the fear reduction account of avoidance conditioning from this and related difficulties, Rescorla and Solomon (1967) have suggested that fear is a "central state" which is imperfectly correlated with peripheral CRs. Thus, to demonstrate the presence of fear during well maintained avoidance behavior:

> "...the concurrent measurement of instrumental behavior and Pavlovian CRs is not the optimal experimental strategy. Indeed, it becomes an irrelevant strategy."

Instead, the presence of fear during well maintained avoidance behavior is inferred by the demonstration that a Pavlovian excitor or inhibitor of fear will increase or decrease, respectively, the rate of avoidance responding when such stimuli are intruded on an avoidance baseline.

For example, in one such experiment, dogs were trained (without an exteroceptive cue) to avoid electric shock by jumping across a barrier in a shuttlebox. Following three days of avoidance training, when the avoidant R was well maintained, the animals were subjected to the following Pavlovian conditioning procedure. A stimulus (CS^+) was paired with shock on one half of the trials. On the other half, however, the CS^+ was paired with another stimulus (CS^-) and shock was not presented. Following this training, both the CS^+ and the CS^- were presented

sixty times each during an avoidance session. By analogy to Pavlovian salivary conditioning studies, the CS^+ will be a conditioned elicitor of fear (assuming that fear is elicited by electric shock), while the CS^- will be a conditioned inhibitor of fear. Thus, if fear is present during the well maintained avoidant R, and if fear motivates the avoidant R, then the intrusion of the CS^+ on the avoidance baseline should produce an increase in avoidance responding, while the intrusion of the CS^- should produce the opposite effect. This was the result obtained.

Today, laboratory findings such as the above constitute the major source of support for the fear reduction account of avoidance conditioning. Yet it is evidence of a limited sort, for though it averts a crisis for fear reduction theory by offering some rationale for supposing that fear is present - and consequently, that reinforcement via fear reduction is possible during well maintained avoidance behavior - and though it supports the notion that fear motivates the avoidant R, it has no direct bearing on the core idea of fear reduction theory - that fear reduction is necessary for the acquisition and maintenance of the avoidant R. Indeed, in recent years avoidance conditioning has been obtained under experimental arrangements which make it difficult to postulate that the avoidant R is reinforced by fear reduction. It is to this development that we now turn.

In 1953, Sidman reported a procedure in which rats were trained to avoid electric shock in the absence of a exteroceptive cue. In Sidman's procedure, which came to be popularly known as "Sidman avoidance", the avoidant R postpones a train of brief, inescapable, electric shocks. The interval by which the avoidant R postpones shock is called the response-shock interval. The interval occurring between two shocks when an avoidant R has not occurred is called the shock-shock interval.

Sidman's demonstration that avoidance responding can be acquired and maintained in the absence of an exteroceptive cue brought into prominence the problem for a fear reduction account of avoidance conditioning first noted by Mowrer with regard to avoidance procedures in which a brief exteroceptive cue terminates before the avoidant R can occur. How can the avoidant R be reinforced by fear reduction when "...there [is] no change in the external stimulus situation..." when the avoidant R occurs?

Sidman's answer - adopted from Schoenfeld's 1950 analysis of avoidance conditioning, which in turn closely resembled the solution tendered by Mowrer in 1942 - took as its starting point the fact that under his and the more typical avoidance conditioning procedure non-avoidance behavior may be immediately followed by S^{-R} while there is always a minimal interval of time between the avoidant R and S^{-R}. Consequently, non-avoidance behavior should be directly suppressed, via punishment, and also, the response

produced stimuli associated with non-avoidance behavior should become conditioned aversive stimuli due to their temporal proximity to S^{-R}. Thus, even in the absence of a response terminated exteroceptive cue, the avoidant R will emerge, due to the punishment of non-avoidance behavior, and be reinforced by the termination of the conditioned aversive stimuli associated with the latter.

Here it should be noted that Sidman's account of how an avoidant R is acquired and maintained in the absence of a response terminated exteroceptive cue involved the notion that the avoidant R is reinforced by the termination of a conditioned aversive stimulus rather than by the termination of fear as produced by a Pavlovian CS. Yet, due to the equivalence of the procedures which are thought to produce both kinds of stimuli, Sidman's analysis applies with equal facility to the fear reduction account of avoidance conditioning.

As was indicated above, the unambiguous applicability of Sidman's analysis of uncued avoidance conditioning is restricted to those experimental situations where a minimal interval of time is programmed between the avoidant R and the occurrence of S^{-R}. Avoidance conditioning has been obtained, however, under experimental arrangements where the foregoing procedural restriction is lifted.

For example, Herrnstein and Hineline (1966) reported a study in which rats, by making a bar press response, could switch from a shock presentation schedule of relative high density to one of lower density. During the

period of low shock density, a response had no programmable effect, and following the occurrence of the first shock the animal was switched back to the high density schedule. Thus, in this study, the animals could reduce the frequency of shock presentation, but could not totally eliminate shock. Also, and perhaps more relevant to the immediate discussion at hand, a bar-press response could (and often did) occur immediately before the shock.

While Sidman's analysis can be applied to the Herrnstein and Hineline experiment - for example, the avoidant R is still, on the average, more temporally removed from the shock than is non-avoidance behavior, and consequently, though the response-produced stimuli associated with the avoidant R should have aversive properties, they should be less aversive than those associated with non-avoidance behavior - it would entail the prediction that avoidance conditioning will be retarded when comparison is made to those procedures in which a minimal interval is programmed between the avoidant R and shock. Yet, "In terms of ease of conditioning...the [Herrnstein and Hineline] procedure is clearly not less effective than earlier ones ..." (Herrnstein, 1969). It appears, therefore, that under this procedure the termination of fear (or of a conditioned aversive stimulus) is not necessary for the conditioning of an avoidant R.

Herrnstein (1969) has argued that with the

elimination of fear (or conditioned aversive stimulus) reduction as a source of reinforcement, the one remaining factor that can account for the conditioning of the avoidant R in the Herrnstein and Hineline experiment is that the avoidant R reduces the frequency of shock occurrence. Extending this argument to the traditional types of avoidance procedures, Herrnstein notes:

> "...that effective avoidance procedures include a common feature, so obvious as to be taken for granted, but possibly the sole necessary condition for avoidance. In each case, the frequency of shock is reduced by the occurrence of the avoidance response, which is to say, an avoidance response avoids the shock."

The present experiment generates data bearing directly on a shock frequency reduction account of avoidance conditioning. Behavior is examined along a continuum of negative reinforcement schedules, ranging from procedures in which responding decreases shock frequency, to procedures in which responding increases shock frequency. To this end, a temporally defined schedule of negative reinforcement is used, derived from the classification of reinforcement schedules put forth by Schoenfeld, Cumming, and Hearst (1956). Basic parameters of this schedule of negative reinforcement are: T_R and $T_{\not R}$, two concurrent repeating time cycles; $P(S^{-R}|R)$, the probability that an electric shock will occur at the end of a T_R cycle (shock onset coinciding with the termination of T_R) if at least one response is made during the T_R cycle; and $P(S^{-R}|\not R)$, the probability that an electric shock will occur at the end of a $T_{\not R}$ cycle if no responses are made during the $T_{\not R}$ cycle.

In the study to be presented here, T_R and $T_{\not R}$ are held constant at 150 secs and 15 secs respectively. The onset of each T_R cycle coincides with the onset of a $T_{\not R}$ cycle with the consequence that each T_R cycle encloses ten complete $T_{\not R}$ cycles. Two groups, each consisting of six rats, are used. A different value of $P(S^{-R}|R)$ is associated with each group (0.0 and 1.0), and this value is held constant across all of the experimental points.

For each group, $P(S^{-R}|\not R)$ is varied through the values of 1.0, 0.2, 0.1, 0.05, and 0.02, in that order.

The foregoing schedule of negative reinforcement has the following properties (Schoenfeld and Cole, 1972): 1) the expression $P(S^{-R}|\not R)/T_{\not R}$ equals the expected mean shock rate when no responding occurs in any of the $T_{\not R}$ cycles; 2) the expression $P(S^{-R}|R)/T_R$ equals the expected mean shock rate when at least one response occurs in every $T_{\not R}$ cycle (and consequently, responding occurs in each of the T_R cycles); and 3) the amount of expected shock frequency reduction (shock rate when no responses are made minus the shock rate actually received) when at least one response occurs in each $T_{\not R}$ cycle is equal to $[P(S^{-R}|\not R)/T_{\not R}]-[P(S^{-R}|R)/T_R]$.

For the animals of Group $P(S^{-R}|R)=1.0$, when at least one response occurs in every $T_{\not R}$ cycle, the expected amount of shock frequency reduction, $[P(S^{-R}|\not R)/T_{\not R}]-[P(S^{-R}|R)/T_R]$, decreases from a positive value to zero as $P(S^{-R}|\not R)$ is reduced from 1.0 to 0.1. Further reductions in $P(S^{-R}|\not R)$, from 0.1 to 0.02, are associated with increasing negative values of shock frequency reduction (i.e., the shock rate increases above that which occurs when no responses are made).

For the animals of Group $P(S^{-R}|R)=0$, when at least one response occurs in every $T_{\not R}$ cycle, the expression $P(S^{-R}|\not R)/T_{\not R}$ equals the expected amount of shock frequency reduction (because $P(S^{-R}|R)/T_R=0$). As $P(S^{-R}|\not R)$

is reduced from 1.0 to 0.02, the expected amount of shock frequency reduction decreases, but remains positive in value. At all values of $P(S^{-R}|R)$, the expected amount of shock frequency reduction will be greater for Group $P(S^{-R}|R)=0$ than for Group $P(S^{-R}|R)=1.0$, with the difference equalling 0.4 shocks per minute.

The discussion of the results of the present experiment will focus on the question of whether or not shock frequency reduction, per se, fully determines responding under the present schedules. This discussion will take as its point of departure the definition of shock frequency reduction referred to above which entails the notion that shock frequency reduction involves shock omission. An alternative definition of shock frequency reduction will then be proposed - that shock frequency reduction is a special case of shock presentation - and the implications of this definition for avoidance theory will be noted.

METHOD

Subjects

The experimental subjects were twelve male Long-Evans hooded rats, 207-228 days old at the start of the experiment. Each animal was individually housed in a cage with Purina lab chow and water continuously available.

Apparatus

The animals were trained in two modified Lehigh Valley Electronics (LVE) model 1316 rat chambers. The modification consisted of replacing the stainless steel work panel (on which two levers were mounted) by an aluminum one, with a single lever (LVE-1352) mounted on its center (between the right and left side of the work panel) 5.1 cm above the grid floor. The lever required approximately 18 gm of static mass for switch closure.

The grid floors of both rat chambers were supplied with scrambled, current-limited, AC by separate Grason-Stadler model 700 shock generators. Electric shock, when presented, was always of 500 msec duration, with the intensity dial set a 1 ma on the shock generator (315V [rms] delivered to the commutator for subsequent scrambling). The lever, the work panel, and the wall opposite the work panel, were included in the shock circuit.

The rat chambers were housed in LVE-1316c experimental enclosures. Mounted on the back of each experimental enclosure was a #47 miniature lamp (operated at 6.3 VAC) which provided general illumination. A BRS Electronics masking noise generator (MN-201), in conjunction with a BRS Electronics audio amplifier (AA-202), delivered masking noise to a speaker mounted on the inside of the experimental enclosure. This masking noise, plus the operation of an exhaust fan (a part of the experimental enclosure), produced a masking noise of approximately 80 db when measured from the middle of the rat chamber by a Brüel and Kjoer type 2203 sound level meter (A scale).

Experimental events were automatically controlled by BRS Electronics logic modules, precision timers, and probability generators. Data were recorded on Sodeco counters and Gerbrands cumulative recorders.

Procedure

Six animals were run in each rat chamber. The first 10 sessions were devoted to preliminary training in which the animals were taken through the following sequence of schedules:

A) Sessions 1-8: T_R = 150 secs and $T_{\not R}$ = 15 secs. $P(S^{-R}|R)=0$ and $P(S^{-R}|\not R)=1.0$. The initiation of a T_R cycle coincided with the initiation of a $T_{\not R}$ cycle. In the absence of a response (lever-press), shock occurred at the

end of $T_{\not R}$, and thereafter, shock occurred every three seconds. The emission of at least one response in $T_{\not R}$ cancelled shock at the end of $T_{\not R}$, and, terminated the train of shocks, if present. Also, if a response was not emitted for the first 11 seconds of a $T_{\not R}$ cycle, the masking noise was terminated, and remained off until a response was emitted. Each session (as throughout the experiment) lasted for 80 minutes (320 $T_{\not R}$ cycles).

B) Session 9: The same as A, except that the masking noise was no longer terminated after the first 110 $T_{\not R}$ cycles had elapsed in the session.

C) Session 10: The same as B, except that shock was no longer presented every 3 seconds following the initial shock after the first 110 $T_{\not R}$ cycles had elapsed in the session. This was the baseline schedule.

Due to a forced shutdown (central air-conditioning failure) of 6 days in the experiment, and due to the fact that animals were at different points in the experiment when the shutdown occurred, the number of baseline sessions given to each animal varied from 32-47 sessions.

Following the completion of baseline training, the animals were divided into two groups. For each rat chamber, the value of $P(S^{-R}|R)$ remained at 0.0 for three animals, and was changed to 1.0 for the other three animals. For each rat chamber, an attempt was made to equate the animals in the two $P(S^{-R}|R)$ groups by matching the animals

for mean response rates over the last seven baseline sessions. With $P(S^{-R}|R)$ held constant, $P(S^{-R}|\not R)$ was varied through the sequence of values: 1.0, 0.2, 0.1, 0.05, and 0.02, in that order. The animals remained on the first experimental point for 42 sessions, and on each of the subsequent experimental points for 21 sessions.

RESULTS AND DISCUSSION

Figures 1 through 6 describe changes in: rate of responding, in responses per minute, (Figures 1 and 2); the number of $T_{\not R}$ cycles containing at least one response (Figures 3 and 4); and rate of responding, in responses per minute, during $T_{\not R}$ cycles containing at least one response (Figures 5 and 6), for groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$, as a function of $P(S^{-R}|\not R)$.

In each figure the six lower panels represent individual functions. The leftmost panels (unfilled circles) represent animals of the group $P(S^{-R}|R)=0$, while the rightmost panels (filled circles) represent animals of the group $P(S^{-R}|R)=1.0$. In constructing the individual functions, behavioral measures obtained over an entire 80 minute sessions were averaged (arithmetic mean) across the last 21 sessions of each experimental point. This in fact included all of the sessions for each experimental point with the exception of $P(S^{-R}|\not R)=1.0$, where 42 sessions were run. In each panel, the data point which is discontinuous with the rest of the function represents the arithmetic mean of the last seven baseline sessions, again, with the behavioral measure obtained over an entire 80 minute session. For each experimental group, the position of an individual function in the two figures associated with each behavioral measure is determined by the animal's rank with regard to rate of responding during the last seven baseline sessions.

The function of the animal showing the highest baseline rate of responding occupies the topmost position in the first figure, while the function of the animal showing the lowest baseline rate of responding occupies the bottom-most position in the second figure, for each of the three behavioral measures, with intermediate positions determined accordingly.

The uppermost panel of each figure represents mean group functions which are coded (unfilled or filled circles) in the same way as the individual functions. Here, the data points at each value of $P(S^{-R}|\not R)$, and the baseline points, were obtained by computing the arithmetic mean of the six corresponding data points of the individual functions. For each behavioral measure, the mean group functions are reproduced twice so that (for example) the mean group functions for Figures 1 and 2 are identical. For all panels (whether individual, or mean group functions), $P(S^{-R}|\not R)$, and the behavioral measure, are represented on logarithmic and linear coordinates respectively.

Figures 1 and 2 show that as $P(S^{-R}|\not R)$ decreases, response rate decreases for all animals. As seen from the averaged group functions, an interaction exists between the variables $P(S^{-R}|\not R)$ and $P(S^{-R}|R)$, for their associated groups show no difference in response rate at $P(S^{-R}|\not R)=1.0$, but show increasing disparity as $P(S^{-R}|\not R)$ decreases, with Group $P(S^{-R}|R)=0$ responding at the higher rate.

Fig. 1: Response rate as a function of $P(S^{-R}|R)$ for rats 1, 3, and 5 of Group $P(S^{-R}|R)=0$, and for rats 2, 4, and 6 of Group $P(S^{-R}|R)=1.0$. The six lower panels represent individual functions. The uppermost panel represents mean group functions (see Results and Discussion section for details).

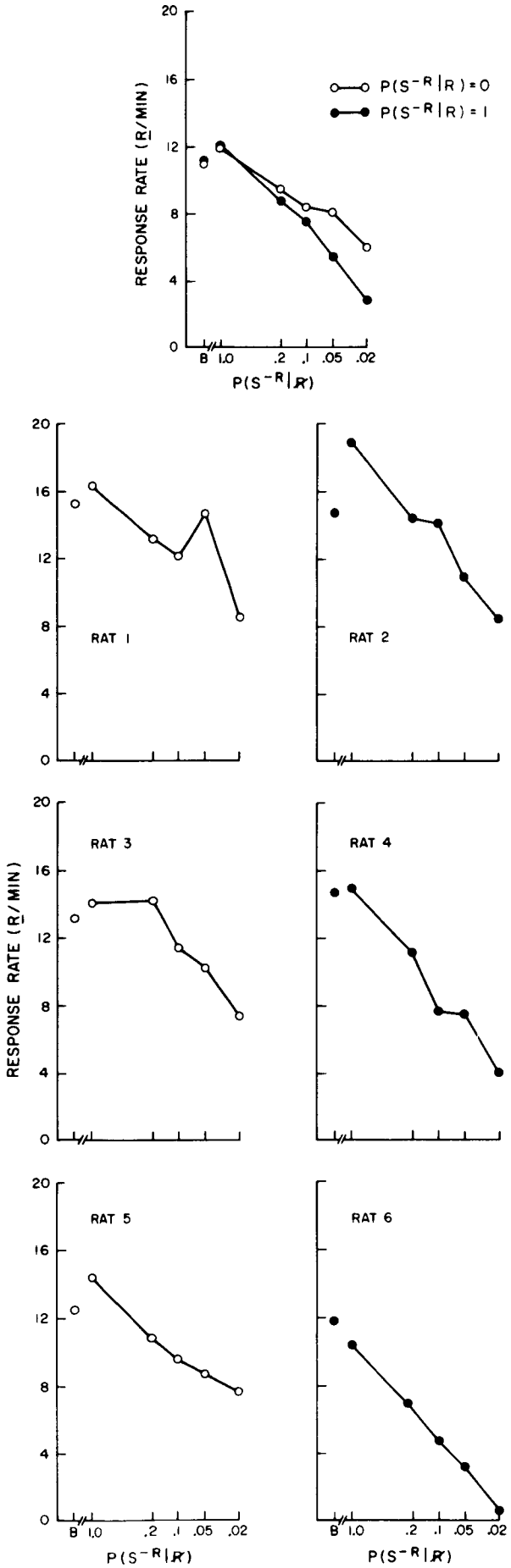

RESPONSE RATE (R/MIN)
P(S⁻R|R)=0
P(S⁻R|R)=1
B 1.0 .2 .1 .05 .02
P(S⁻R|R)
RAT 1
RAT 2
RAT 3
RAT 4
RAT 5
RAT 6

Fig. 2: Response rate as a function of $P(S^{-R}|R)$ for rats 7, 9, and 11 of Group $P(S^{-R}|R)=0$, and for rats 8, 10, and 12 of Group $P(S^{-R}|R)=1.0$. The six lower panels represent individual functions. The uppermost panel represents mean group functions (see Results and Discussion section for details).

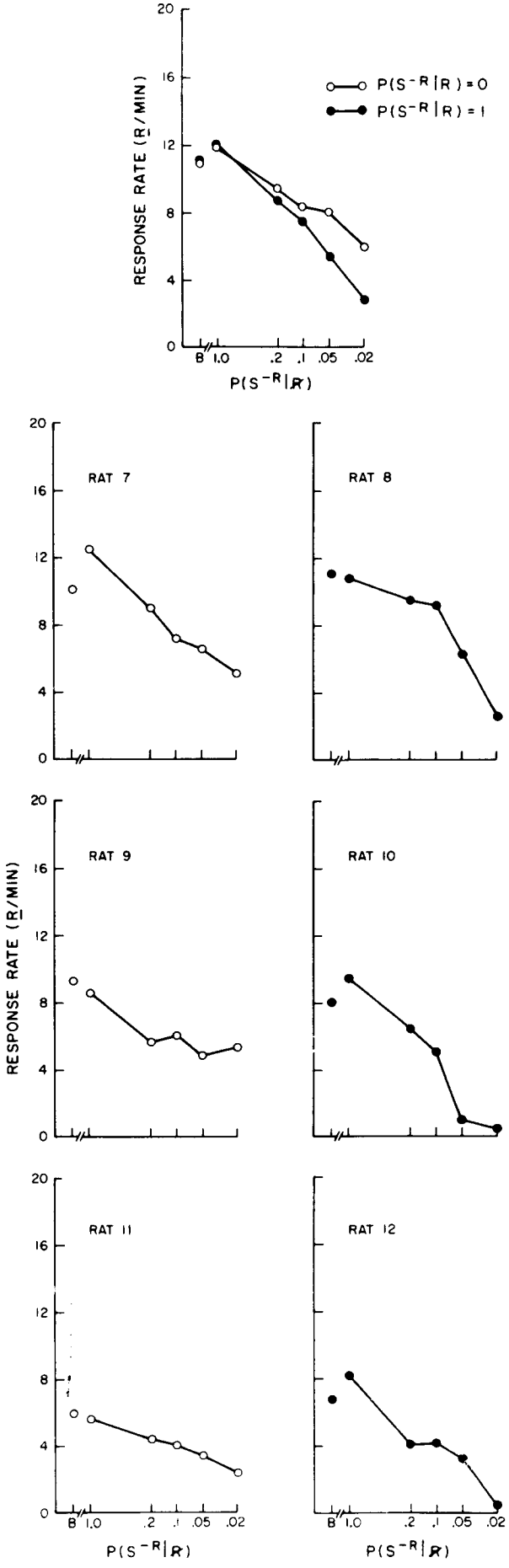

RESPONSE RATE (R/MIN)
P(S⁻R|R) = 0
P(S⁻R|R) = 1
P(S⁻R|R)
B 1.0 .2 .1 .05 .02
RAT 7
RAT 8
RAT 9
RAT 10
RAT 11
RAT 12
0
4
8
12
16
20

Fig. 3: The number of $T_{\not R}$ cycles sampled by at least one response as a function of $P(S^{-R}|\not R)$ for rats 1, 3, and 5 of Group $P(S^{-R}|R)=0$, and for rats 2, 4, and 6 of Group $P(S^{-R}|R)=1.0$. The six lower panels represent individual functions. The uppermost panel represents mean group functions (see Results and Discussion section for details).

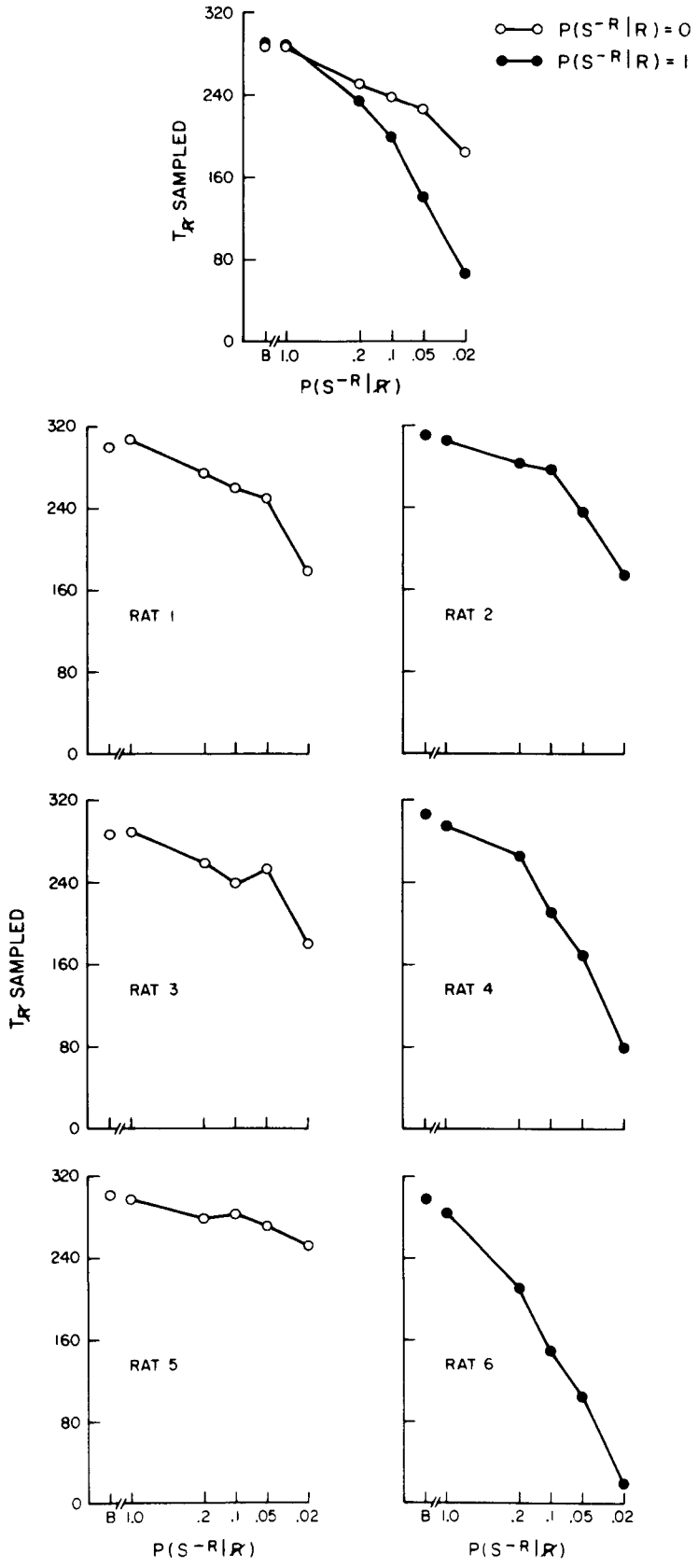

P(S⁻R|R) = 0
P(S⁻R|R) = 1
T_R SAMPLED
320
240
160
80
0
B 1.0 .2 .1 .05 .02
P(S⁻R|R)
RAT 1
RAT 2
RAT 3
RAT 4
RAT 5
RAT 6

Fig. 4: The number of $T_{\not R}$ cycles sampled by at least one response as a function of $P(S^{-R}|\not R)$ for rats 7, 9, and 11 of Group $P(S^{-R}|R)=0$, and for rats 8, 10, and 12 of Group $P(S^{-R}|R)=1.0$. The six lower panels represent individual functions. The uppermost panel represents mean group functions (see Results and Discussion section for details).

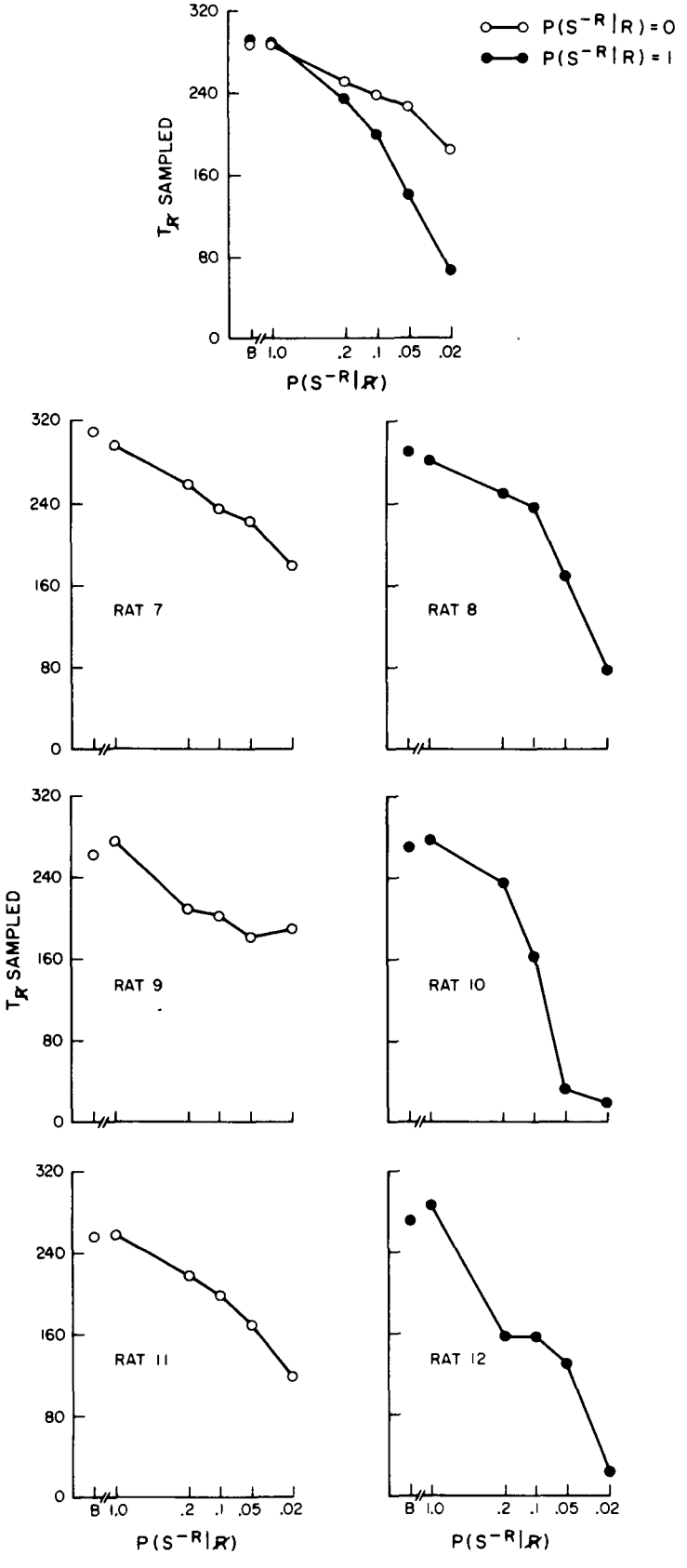

P(S⁻R|R) = 0
P(S⁻R|R) = 1
T_R SAMPLED
320
240
160
80
0
B 1.0 .2 .1 .05 .02
P(S⁻R|R)
RAT 7
RAT 8
RAT 9
RAT 10
RAT 11
RAT 12

Fig. 5: Response rate during $T_{\not R}$ cycles sampled by at least one response as a function of $P(S^{-R}|\not R)$ for rats 1, 3, and 5 of Group $P(S^{-R}|R)=0$, and for rats 2, 4, and 6 of Group $P(S^{-R}|R)=1.0$. The six lower panels represent individual functions. The uppermost panel represents mean group functions (see Results and Discussion section for details).

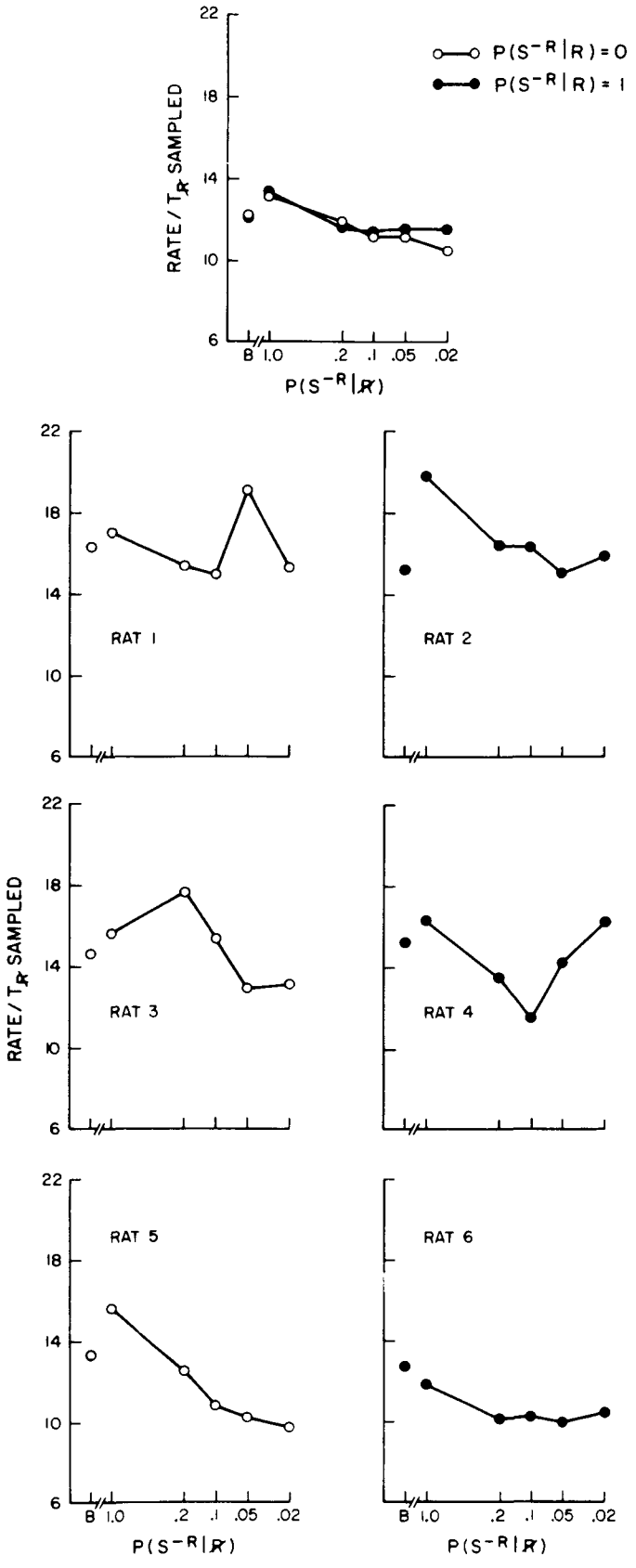
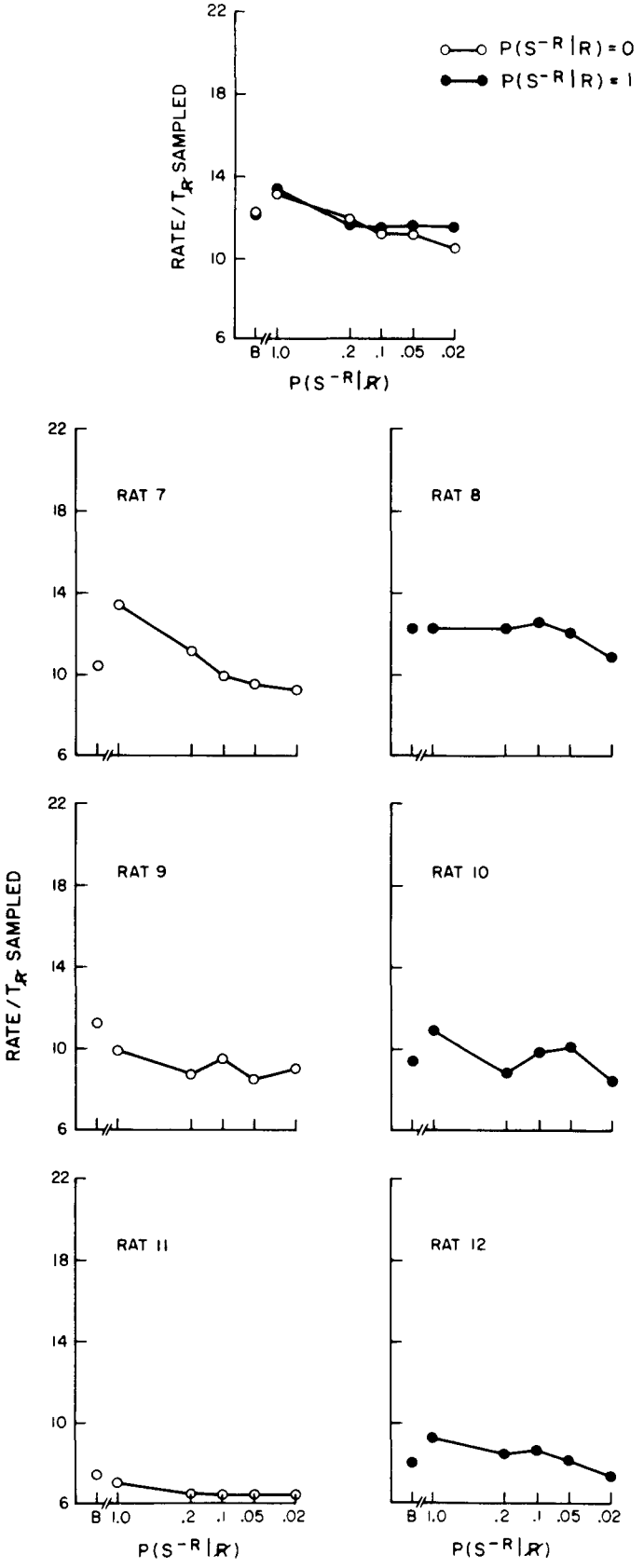

P(S⁻R|R) = 0
P(S⁻R|R) = 1
RATE / T_R SAMPLED
22
18
14
10
6
B 1.0 .2 .1 .05 .02
P(S⁻R|R)
RAT 1
RAT 2
RAT 3
RAT 4
RAT 5
RAT 6

Fig. 6: Response rate during $T_{\not R}$ cycles sampled by at least one response as a function of $P(S^{-R}|\not R)$ for rats 7, 9, and 11 of Group $P(S^{-R}|R)=0$, and for rats 8, 10, and 12 of Group $P(S^{-R}|R)=1.0$. The six lower panels represent individual functions. The uppermost panel represents mean group functions (see Results and Discussion section for details).


P(S⁻R|R) = 0
P(S⁻R|R) = 1
RATE / T_R SAMPLED
22
18
14
10
6
B 1.0 .2 .1 .05 .02
P(S⁻R|R)
RAT 7
RAT 8
RAT 9
RAT 10
RAT 11
RAT 12

Figures 3 and 4 show that as $P(S^{-R}|\not R)$ decreases the number of $T_{\not R}$ cycles containing at least one response decreases for all animals. As with the response rate measure, the mean group functions show an interaction between the variables $P(S^{-R}|\not R)$ and $P(S^{-R}|R)$: the number of $T_{\not R}$ cycles containing at least one response falls off at a faster rate for Group $P(S^{-R}|R)=1.0$ than for Group $P(S^{-R}|R)=0$, as $P(S^{-R}|\not R)$ is decreased. Throughout the range of $P(S^{-R}|\not R)$, Group $P(S^{-R}|R)=0$ responds in more $T_{\not R}$ cycles than Group $P(S^{-R}|R)=1.0$, except at $P(S^{-R}|\not R)=1.0$, where there there is no difference.

The number of $T_{\not R}$ cycles containing at least one response provides information concerning the proportion of total session time taken up by responding, and as such, may bear more directly on the notion of "response strength" than does the measure of rate of responding (see Baum, 1973). If, for example, rate of responding remained constant as $P(S^{-R}|\not R)$was reduced, but the number of $T_{\not R}$ cycles containing at least one response decreased, the opinion might be tendered that behavioral maintenance was weakened as $P(S^{-R}|\not R)$ decreased. If, on the other hand, rate of responding decreased, without a concomitant decrease in the number of $T_{\not R}$ cycles containing at least one response, argument might be made that decreases in $P(S^{-R}|\not R)$ served mainly to reduce the number of short IRTs ("bursts") which perhaps reflects more on "emotionality" than on "response strength". Under the present procedure these complex-

ities are averted, for decreasing $P(S^{-R}|\not R)$ produces large decreases in both rate of responding and the number of $T_{\not R}$ cycles containing at least one response.

Figures 5 and 6 show rate of responding during $T_{\not R}$ cycles containing at least one response as a function of $P(S^{-R}|\not R)$. For each experimental session, this measure (in responses per minute) is obtained by multiplying the number of $T_{\not R}$ cycles containing at least one response by 0.25 min (the duration of a $T_{\not R}$ cycle), and then dividing the total number of responses by this quantity. Here, since only those 15 sec time samples during which the animal has responded are used to compute a response rate, the resulting measure may be comparable to a "running rate" (i.e., rate of responding during total experimental time less the sum of the time periods intervening between the onset of S^{+R}, or S^{-R}, and the next response.)

That rate of responding during $T_{\not R}$ cycles containing at least one response shares at least some of the properties of the "running rate" measure is illustrated by the functions of Figures 5 and 6. To the extent that changes occur, response rate during $T_{\not R}$ cycles containing at least one response declines as $P(S^{-R}|\not R)$ is reduced. Yet, with the exception of rats 2, 5, 7, and 12, these reductions are minimal. Also, with regard to $P(S^{-R}|R)$, groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$ respond at approximately equal rates throughout the entire range of

$P(S^{-R}|\not R)$. This relative insensitivity of rate of responding during $T_{\not R}$ cycles containing at least one response to changes in the values of $P(S^{-R}|R)$ and $P(S^{-R}|\not R)$ is consistent with the finding (obtained under schedules of positive reinforcement) that "running rate" is a relatively insensitive measure for a wide range of independent variables (e.g., Farmer and Schoenfeld, 1967).

A number of the results obtained in the present study are consistent with the notion that the degree of response maintenance obtained under a given pair of $P(S^{-R}|\not R)$ and $P(S^{-R}|R)$ values is dependent solely on the expected amount of shock frequency reduction produced when responding occurs in each $T_{\not R}$ cycle. Thus, the findings that: 1) rate of responding and the number of $T_{\not R}$ cycles containing at least one response decline with decreases in $P(S^{-R}|\not R)$; 2) Group $P(S^{-R}|R)=0$ responds at a higher rate and samples a greater number of $T_{\not R}$ cycles than Group $P(S^{-R}|R)=1.0$ across all values of $P(S^{-R}|\not R)$, except at $P(S^{-R}|\not R)=1.0$; and 3) for each behavioral measure, the functions for groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$ appear to belong to the same family of functions, are all consistent with the notion that for each group of animals the degree of response maintenance is solely determined by the value of the expression $[P(S^{-R}|\not R)/T_{\not R}] - [P(S^{-R}|R)/T_R]$ (the expected amount of shock frequency reduction produced when responding occurs in each $T_{\not R}$ cycle) irrespective of the particular values of $P(S^{-R}|\not R)/T_{\not R}$ and $P(S^{-R}|R)/T_R$.

This notion, however, is not consistent with the fact that rate of responding declines more steeply for Group $P(S^{-R}|R)=1.0$ than for Group $P(S^{-R}|R)=0$ as $P(S^{-R}|\not R)$ is reduced. If the amount of shock frequency reduction is the sole determinant of response maintenance, then the functions for groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$ should be parallel since the difference in the expected amount of shock frequency reduction between the two groups remains constant at 0.4 shocks per minute as $P(S^{-R}|\not R)$ is reduced. The divergence in the two groups suggests that the variable $P(S^{-R}|R)$ influences the animals' behavior in a manner that is not fully encompassed by its role in determining the amount of shock frequency reduction.

This conclusion is not contravened when shock frequency reduction is alternatively defined as the difference between the shock rate obtained when no responding occurs, and the shock rate actually received irrespective of the proportion of $T_{\not R}$ cycles containing at least one response (de Villiers, 1972, 1974). Tables 1 and 2 show, for groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$ respectively, the obtained mean shock frequency reduction at each value of $P(S^{-R}|\not R)$, for each animal, plus the group means. The last column of Table 2 shows the difference between the group means for groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$ at each value of $P(S^{-R}|\not R)$. In constructing Tables 1 and 2, the shock frequency reductions (shock rate, per minute, when no responses are made minus the shock rate actually received)

Table I

Amount of shock frequency reduction for each animal of Group $P(S^{-R}|R)=0$, plus group means, at each value of $P(S^{-R}|\not R)$. See Results and Discussion section for details.

$P(S^{-R}|\not R)$	RAT						
	1	3	5	7	9	11	GROUP MEAN
1.00	3.82	3.60	3.71	3.70	3.42	3.22	3.58
0.20	0.67	0.52	0.70	0.64	0.54	0.54	0.60
0.10	0.33	0.30	0.35	0.29	0.24	0.27	0.30
0.05	0.15	0.14	0.17	0.14	0.12	0.10	0.14
0.02	0.05	0.05	0.06	0.04	0.04	0.02	0.04

Table 2

Amount of shock frequency reduction for each animal of Group $P(S^{-R}|R)=1.0$, plus group means, at each value of $P(S^{-R}|\not R)$. Negative numbers refer to instances where shock rate is above that which would be expected when no responding occurs. The rightmost column is obtained by subtracting the mean shock frequency reduction for Group $P(S^{-R}|R)=1.0$ from the mean shock frequency reduction for Group $P(S^{-R}|R)=0$ at each value of $P(S^{-R}|\not R)$. See Results and Discussion section for details.

$P(S^{-R}|\not R)$	RAT 2	4	6	8	10	12	GROUP MEAN	DIFFERENCE
1.00	3.42	3.30	3.19	3.18	3.12	3.22	3.24	0.34
0.20	0.31	0.27	0.15	0.23	0.21	0.14	0.22	0.38
0.10	-0.05	-0.12	-0.15	-0.11	-0.15	-0.09	-0.11	0.41
0.05	-0.21	-0.26	-0.26	-0.27	-0.11	-0.18	-0.22	0.36
0.02	-0.22	-0.19	-0.06	-0.21	-0.05	-0.08	-0.14	0.18

obtained over 80 minute sessions were averaged (arithmetic mean) across the last 21 sessions of each experimental point (see Method section). The group means at each value of $P(S^{-R}|\not{R})$ were obtained by computing the arithmetic mean of the six corresponding means of the individual animals.

Table 2 shows the difference in the amount of shock frequency reduction obtained between groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$ remains approximately constant across variations in $P(S^{-R}|\not{R})$ - with a mean of 0.37 shocks per minute, and a range of 0.07 shocks per minute - when the difference obtained at $P(S^{-R}|\not{R})=0.02$ (0.18 responses per minute) is excluded from consideration. Thus, even with this alternative definition of shock frequency reduction an inconsistency remains between the fact that rate of responding shows a steeper decline for Group $P(S^{-R}|R)=1.0$ than for Group $P(S^{-R}|R)=0$ as $P(S^{-R}|\not{R})$ is reduced and the notion that responding in the present experiment is solely dependent on the amount of shock frequency reduction produced.

That the variable $P(S^{-R}|R)$ exercises an influence over responding which is not fully encompassed by its role in determining shock frequency reduction serves to emphasize a property of the present schedule of negative reinforcement which has not yet been considered. When $P(S^{-R}|R)$ is equal to zero the minimum interval of time

between a response and a shock is equal to the duration of T_R (15 secs in the present experiment). When $P(S^{-R}|R)$ is greater than zero, however, this constraint is lifted, and a shock may occur immediately after a response. Thus, the possibility might be considered that shock frequency reduction and the minimal interval of time permitted between a response and a shock jointly determine responding under the present schedule. This approach gains credence from the work of Hineline and his associates who have demonstrated that responding may be acquired and maintained when: a) R postpones the occurrence of shock without reducing shock frequency (Hineline, 1970); and b) R produces shock but reduces shock frequency (Lambert, Bersh, Hineline, and Smith, 1973), for the demonstration "... that either shock-frequency reduction or delay of shock onset is a sufficient basis for avoidance conditioning" suggests that both of these variables control responding under an avoidance schedule.

Argument will be made, however (following Schoenfeld, 1969, and Schoenfeld and Cole, 1972), that this mode of analysis is misconceived. It is symptomatic of the notion that shock frequency reduction involves shock omission, and consequently, that it is something other than the distribution of shocks, and the relationships between the distributions of responses and shocks, which follow upon the operation of intruding shocks into an ongoing sequence of responses. When shock frequency reduction is

correctly construed as a special case of shock intrusion such a distinction disappears, and coincidentally, because shock frequency reduction becomes part and parcel of the variables which control responding under any schedule (positive or negative) "...The phenomeon of avoidance simply disappears as a separate category of behavior, or at least becomes a derivable spin-off from a more general treatment of behavior." (Schoenfeld, 1969).

A number of considerations recommend the notion that shock frequency reduction is best conceived as a special case of the operation of intruding shocks into an ongoing sequence of responses:

A) The conceptualization of shock frequency reduction as shock omission owes much of its currency to the analytical practice of segmenting behavior and stimulus intrusions into independent behavioral episodes (i.e., discrete trials). By such modes of thought a sense appears in which the avoidant R occurs in isolation, for it is set apart from subsequent shocks by the temporal boundaries of a trial. When artificial boundaries are ignored, however (as with free operant methodology), shock frequency reduction is most aptly described as a negative correlation between rates of responding and shock presentation (see Baum, 1973). Since shocks must be presented (in the presence of ongoing responding) for such a correlation to exist, shock frequency reduction becomes identified as a special case of shock intrusion.

B) The conceptualization of shock frequency reduction as shock omission may also be attributed to the designation of electric shock as a "negative reinforcer" which in turn is due to the many experimental arrangements in which electric shock functions as a "punishing stimulus". It has been demonstrated, however, that under certain experimental arrangements responding will be maintained when it increases the frequency of shock occurrence - as, for example, under fixed interval schedules of shock presentation (Morse and Kelleher, 1970; McKearney, 1972; Stretch, 1972). Such demonstrations bring into question the advantage to be obtained for behavior theory by imputing reinforcing properties ("positive" or "negative") to stimuli per se. "Rather the results of intruding a stimulus into the behavioral stream depend on the parameters of the stimulus, of the organism, and of the stimulus delivery schedule." (Schoenfeld and Cole, 1972).

Such considerations remove a barrier to the treatment of shock frequency reduction as shock intrusion. Even more, since "...the distinction between positive and negative reinforcement schedules [now] becomes questionable" (Schoenfeld and Cole, 1972) or at least unnecessary, they emphasize the ad hoc nature of treating an avoidance schedule as shock omission, and consequently, as different in kind from other behavioral procedures. Insofar as a unification of schedule operations is indicated it appears best to treat all schedules as special cases of the oper-

ation of intruding a stimulus into an ongoing sequence of responses, for this appears to be the only operation that is capable of encompassing the variagated set of relationships between responding and stimulation which have now been shown to maintain behavior. Whatever its modus operandi, such a unification will not include stimulus omission as a schedule operation despite its intuitive applicability to the avoidance case, since "...no parallel case can be drawn from schedules involving 'positive reinforcement'..." (Schoenfeld, 1969). Also, the treatment of avoidance as shock omission would make paradoxical the maintenance of responding under schedules of shock presentation, since it would then appear that both shock presentation and shock omission are sufficient to maintain behavior.

C) The conceptualization of shock frequency reduction as a special case of shock intrusion leads to the dissolution of the "avoidance paradox" - how can stimulus non-occurrence reinforce behavior. As Schoenfeld (1969) has noted, "The problem of operant avoidance behavior has seemed to be identifying the reinforcement for it. The 'avoidance paradox' arose from the definition of avoidance as behavior leading to non-occurrence of certain stimuli, with the consequent need to rationalize stimulus non-occurence as reinforcing." This in turn led to the postulation of expectancy-as an attempt to explain how stimulus non-occurrence (as such) could effect a preceding avoidant R - and to the postulations of fear and conditioned aversive

stimulus - in an attempt to place a reinforcing event in contiguous relation to the avoidant R. It is within this context of theory construction that the shock frequency reduction account of avoidance conditioning appears to obtain much of its force, for here, appeal is ostensibly made to the relationship between responding and shock as the direct determiner of avoidance responding and not to the existence of hypothetical entities which "...are not yet accessible for measurement or experimental manipulation." (Schoenfeld, 1969). Such an appeal is uninformed, however, when shock frequency reduction is construed as shock omission, for the "avoidance paradox" - and consequently, the very reason for postulating such entities as expectancy or fear - is simply ignored or left unattended. Only by conceptualizing shock frequency reduction as a special case of shock intrusion is the "avoidance paradox" resolved (through the dissolution thereof) without recourse to the hypothetical entities which give avoidance theory its distinctive flavor.

In summary, the conceptualization of shock frequency reduction as a special case of the operation of intruding shocks into an ongoing sequence of responses 1) is entailed by free operant methodology; 2) is necessitated by any attempt to organize schedules into a unitary framework; and 3) results in the dissolution of the avoidance paradox. Ironically, when shock frequency reduction is so

conceived a sense emerges in which it fully determines responding under an avoidance schedule (when non-schedule variables are excluded from consideration), since shock frequency reduction becomes part and parcel of the distribution of stimuli, and the relationships between the distribution of responses and stimuli, which encompass all schedule related determinants of behavior. More importantly, by this analysis avoidance responding is solely distinguished from that generated by any other stimulus schedule by the limiting values of identical controlling variables. Such limiting values, however, do not distinguish avoidance in any real sense, since the boundaries they describe are merely nominal. As noted above, responding may be maintained by electric shock in the absence of shock frequency reduction. Such procedures in turn are related to avoidance via the parameters of the $t\text{-}\tau$ systems (Schoenfeld and Cole, 1972), the manipulation of which determines a continuous schedule space which encompasses (by force, or as limiting cases) all stimulus intrusion procedures. Since shock frequency reduction is not necessary for the maintenance of behavior by electric shock, and since all schedule operations are part "...of the same parametric continua of experimental operations and variables..." (Schoenfeld, 1969) avoidance becomes designated solely on the basis of convention.

APPENDIX

Tables 3, 4, 5, and 6. Mean response rate (responses per minute) and mean number of $T_{\not R}$ cycles containing at least one response presented in 7 day blocks. Tables 3 and 4 show response rates for animals of Groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$ respectively. Tables 5 and 6 show the number of $T_{\not R}$ cycles containing at least one response for animals of Groups $P(S^{-R}|R)=0$ and $P(S^{-R}|R)=1.0$ respectively.

Table 3

Response Rate in 7 day blocks for Group $P(S^{-R}|R)=0$.

	$P(S^{-R}/R)$				
RAT	1.00	0.20	0.10	0.05	0.02
1					
	14.84	12.80	11.09	13.96	9.81
	17.75	15.02	12.30	15.93	6.08
	16.23	11.41	12.88	14.12	9.50
3					
	13.54	12.55	12.30	9.25	8.93
	13.34	14.52	10.54	10.93	7.65
	15.29	15.47	11.27	10.34	5.41
5					
	14.44	10.38	9.01	8.42	8.25
	14.34	10.85	9.87	8.06	5.96
	14.55	11.24	9.85	9.63	8.67
7					
	12.78	9.11	7.14	6.89	4.90
	12.57	8.97	7.16	6.40	4.93
	12.05	8.86	7.35	6.54	5.55
9					
	8.85	5.42	7.03	4.92	4.46
	8.55	5.48	5.47	4.67	5.60
	8.01	6.05	5.48	4.77	5.91
11					
	5.41	4.20	4.04	3.34	2.93
	5.62	4.40	4.11	3.27	2.12
	5.74	4.54	3.69	3.56	2.07

Table 4

Response rate in 7 day blocks for Group $P(S^{-R}|R)=1.0$.

RAT	$P(S^{-R}\|R)$ 1.00	0.20	0.10	0.05	0.02
2					
	19.36	15.41	13.71	12.22	7.16
	19.92	13.44	14.24	10.78	7.58
	17.31	14.45	14.36	9.82	10.62
4					
	14.68	11.21	8.35	6.41	6.24
	15.28	10.96	6.25	7.01	4.44
	14.85	11.24	8.04	8.86	1.24
6					
	11.27	6.88	5.04	4.21	0.47
	10.81	6.71	5.03	3.36	0.40
	9.26	6.26	4.06	1.99	0.86
8					
	9.87	9.87	9.38	7.49	1.85
	10.72	9.03	9.30	6.45	3.66
	11.80	9.73	9.02	4.94	2.17
10					
	10.64	6.74	5.59	1.86	1.24
	8.94	5.83	6.17	0.33	0.05
	8.67	6.62	3.11	0.89	0.15
12					
	8.08	6.29	4.42	4.56	0.83
	8.56	4.01	3.69	2.64	0.48
	8.03	2.04	4.47	2.57	0.20

Table 5

Number of $T_{\not R}$ cycles containing at least one response for Group $P(S^{-R}|R)=0$

RAT	$P(S^{-R}\|\not R)$ = 1.00	0.20	0.10	0.05	0.02
1					
	305.71	270.57	258.28	249.00	190.71
	308.43	280.57	256.57	245.57	156.43
	303.43	268.71	263.43	248.28	185.28
3					
	291.86	258.57	230.28	258.57	211.28
	287.28	261.71	234.71	254.43	191.28
	286.00	255.14	248.00	242.43	135.14
5					
	297.14	271.00	266.86	274.86	266.71
	296.14	262.43	286.86	257.00	221.14
	298.28	299.86	293.71	282.43	264.57
7					
	298.71	265.43	231.43	225.00	176.00
	294.00	253.43	229.57	221.86	174.57
	296.57	257.86	240.00	220.86	185.86
9					
	280.00	194.14	222.14	171.00	180.00
	274.14	209.86	186.14	182.43	183.28
	267.00	219.14	199.00	188.86	205.00
11					
	263.57	208.71	202.00	167.43	142.71
	255.57	219.28	201.71	166.57	107.00
	252.71	222.28	192.00	173.28	103.43

Table 6

Number of $T_{\not R}$ cycles containing at least one response for Group $P(S^{-R}|R)=1.0$.

	$P(S^{-R}\|\not R)$				
RAT	1.00	0.20	0.10	0.05	0.02
2					
	303.28	290.00	277.57	258.86	154.71
	302.57	275.57	277.57	236.86	156.00
	306.28	280.00	273.43	206.00	204.43
4					
	294.00	256.43	223.00	159.43	123.71
	294.57	263.00	193.71	153.00	86.86
	292.00	274.57	214.57	191.14	25.14
6					
	282.86	211.14	165.14	137.28	15.28
	288.57	212.28	153.71	110.28	13.28
	276.57	206.71	124.71	61.28	24.86
8					
	282.00	260.14	239.86	203.14	54.71
	278.86	248.14	237.00	168.14	108.71
	285.71	243.43	230.43	132.28	64.71
10					
	280.14	241.57	194.00	53.71	49.86
	275.43	224.71	193.28	13.00	2.00
	275.43	234.28	98.28	30.43	3.14
12					
	285.43	245.43	157.86	183.71	34.57
	285.86	149.86	135.86	103.57	22.00
	285.43	74.00	173.00	98.86	9.43

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