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A SYSTEMATIC INVESTIGATION OF THE CONDITIONED FACILITATION
PHENOMENON WITH HUMAN BEINGS AS SUBJECTS

by

Gladys Olivia Bright

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INTRODUCTION

The purpose of the present study was to investigate the effects of non-contingent positive reinforcement upon a lever pulling baseline maintained by positive reinforcement. The results of a number of previous studies have demonstrated both facilitation and suppression of behavior during a stimulus preceding a non-contingent reinforcer.

It has been generally accepted that disruption of an ongoing behavior is indicative of "emotional behavior." Typically, this disruptive effect is produced by superimposing a non-contingent aversive event upon an ongoing operant behavior. This form of "emotional behavior" was first defined experimentally by Estes and Skinner, (1941). In that study, a rat's lever pressing was maintained by food reinforcement. A short duration stimulus was presented independently of the operant behavior and terminated with a brief, unavoidable shock. After a number of these stimulus-shock pairings, conditioned suppression became evident in a decrease in response rate during the stimulus. The previously neutral stimulus, then, became a conditioned stimulus (CS) which alone could decrease response rate (conditioned suppression).

The conditioned suppression phenomenon has been demonstrated in a variety of organisms such as rats (Estes and Skinner, (1941); guinea pigs (Valenstein, 1959); fish (Geller, 1963; 1964); dogs (Lindsley and Jetter, 1953); cats (Brady and Conrad, 1960); and pigeons (Azrin, 1956). Data also have been obtained that indicate

conditioned suppression in human subjects, (Mulder, Lyon, and Pott, 1967). These data indicate the generality of the suppression phenomenon over species. The degree of suppression over species, however, may be a reflection of species variation or a differential sensitivity to certain manipulated variables.

Various reasons have been offered to explain the occurrence of conditioned suppression. Two of the more tenable interpretations of the phenomenon are the interference hypothesis (Kamin, 1965) and the punishment hypothesis (Hunt and Brady, 1951). The interference hypothesis maintains that certain kinds of conditioned respondents, such as crouching, freezing, urinating, and defecating, interfere with the ongoing operant behavior of an organism. Such interference can be of two types - covert response interference or overt behavioral interference. The above behavioral examples fall into the latter category. This interpretation of conditioned suppression is difficult to document due to the fact that there is a lack of specificity in defining the interfering behaviors. Such behaviors are discussed as merely being representative of respondents.

The punishment hypothesis claims that the disruption of an ongoing operant behavior is the result of punishment, even though there is only an adventitious contingency between the behavior and the punishment. The basic assumption of this hypothesis is that there is a high probability of the aversive event being delivered when the organism is completing a response during the early stages of the suppression procedure. In this instance, much of the behavior will be punished and the organism will suppress all behavior. The

tenability of this interpretation, however, is questionable, since it cannot account for the rapid acquisition of the suppression response. Also, it does not account for the suppression obtained during a CS presented while an organism is engaged in an operant behavior when previously there was no opportunity for the operant behavior to be emitted.

Although typically associated with the presentation of an aversive event, emotional behavior need not always be the result of such an event (Millenson, 1967). Herrnstein and Morse (1957), for example, describe the converse of conditioned suppression - conditioned enhancement or facilitation. With this phenomenon there was an increase in an operant response rate during the presentation of a stimulus that had previously been paired with positive reinforcement. Although the ongoing behavior was not suppressed, it was disrupted and was, therefore, interpreted as emotional behavior.

The facilitation phenomenon has not been analyzed as extensively as has conditioned suppression. Several investigators, however, have examined facilitation while manipulating certain variables which may account for the occurrence of the phenomenon. One such variable, for example, could be the reinforcement schedule employed. Pliskoff (1963) demonstrated facilitation in rats using several different multiple variable interval-variable interval (VI-VI) schedules of reinforcement, with each VI correlated with a particular stimulus. Herrnstein and Morse (1957) used a schedule of differential reinforcement of low rates (DRL) of 5 min. and also obtained facilitation with pigeons. A fixed interval (FI) schedule of reinforcement

yielded facilitation in two studies by Estes (1943 and 1948).

A second variable which may be of importance in the occurrence of conditioned enhancement is the type of reinforcement used to maintain the operant response rate. Some investigators have made use of consumables such as food and water (Estes, 1943; 1948) and non-consumables such as electrical brain stimulation (Brady, 1961). The results of these studies have rather reliably demonstrated the conditioned enhancement effect.

It seems quite clear that "anxiety," resulting from the anticipation of an aversive event, should disrupt an ongoing operant behavior. It also seems logical that anticipation of "reward," or a positively reinforcing event, should lead to a facilitative effect. But, no matter how logical it appears to be, there exists evidence to question this latter point. The fact that a stimulus paired with positive reinforcement does not always produce facilitation was demonstrated by Azrin and Hake (1969). They observed that a CS, when paired with food, water, or intracranial stimulation, suppressed an ongoing bar-press response. It was also observed by Pliskoff (1961; 1963) that animals would suppress during a stimulus that signaled a change from a variable interval schedule of low frequency reinforcement to a schedule of high reinforcement frequency. In other words, the animals would stop responding when a change from a "less favorable" to a "more favorable" schedule of reinforcement was signaled.

Several hypotheses have been proposed to explain the occurrence of both facilitation and suppression under a positive baseline. A

current theory to explain facilitation involves "superstitious conditioning" (Herrnstein and Morse, 1957). This theory proposes that an adventitious correlation occurs between the operant response and the non-contingent reinforcement. This theory of facilitation tends to coincide quite closely with the punishment interpretation of the occurrence of conditioned suppression. In other words, during the early stages of the conditioning procedure, there is a high probability of the positively reinforcing event being delivered when the organism is making a response.

Azrin and Hake (1969) have explained the occurrence of conditioned suppression in terms of a competing behavior or of an "underlying emotional state of heightened preparedness." The basic difficulty with this interpretation, however, is that such heightened preparedness does not lend itself to empirical investigation. The present study was designed to determine if the conditions that Azrin and Hake found to be operative with animals are also present with human beings as subjects.

METHOD

Subjects

The subjects were four male residents of the Fort Custer State Home for the Retarded, Augusta, Michigan. The subjects ranged in age from 8-6 to 17-2 years with a mean age of 11-6 years. The mean IQ of the four was 45 with a range of 26 to 62.

Apparatus

The response console, located in a small sound attenuated room, consisted of a 6 x 6 x 6 inch wooden box. A 10 inch handle attached to the right side of this box served as the response lever. The excursion of the lever was approximately five inches and required a force of about 10 grams to operate the response counter. A buzzer, mounted inside of the box, served as the conditioned stimulus (CS). The response console was attached to a small table near a Gerbrands M&M candy dispenser that delivered reinforcers.

The entire experiment was programmed by appropriate relay circuitry located in an adjacent room. Data were recorded from electromagnetic counters, a running-time meter, and a Gerbrands cumulative recorder.

Training procedure

This procedure consisted of four individual sessions devoted primarily to training each subject to pull the response lever at a relatively stable rate, approximately one response every two to three seconds. The subjects received reinforcement for lever pulling on a schedule of continuous reinforcement (CRF). After this behavior became stable, the schedule was gradually shifted to a variable interval (VI) of two minutes. Under this schedule, the time between reinforcements ranged from 10 to 230 seconds, with a mean of 120 seconds. The sequence of reinforcement presentation was as follows: 40, 10, 150, 230, 220, 70, 180, 170, 90, 200, 20, and 60 seconds.

Following the stabilization of the response rate, a buzzer with

a 10 second duration was presented for varying inter-stimulus intervals. This was done to assure that it would have no disruptive effects on the lever pulling rate.

Enhancement procedure

The conditioning sessions were begun by pairing the delivery of non-contingent positive reinforcement coincidentally with the termination of the buzzer. The experiment was mechanically programmed to prevent the delivery of reinforcement during the buzzer.

In this procedure, the duration of the buzzer across sessions varied within a range of 5 to 40 seconds with a 10, 20, 40, 5, and 10 second sequence. The subjects responded under each of these CS durations for two consecutive 24-minute sessions. Each subject received 24 reinforcers during the conditioning sessions; 12 response contingent and 12 non-contingent or "free."

RESULTS

In order to calculate the degree of behavioral change exhibited by each subject, an inflection ratio was used (Hunt, Jernberg, and Brady, 1952). Inflection, or facilitation, was equal to $\frac{CS-C}{C}$, where CS was the total number of responses emitted during the conditioned stimulus and C, or control, was the number of responses emitted in a period just prior to CS onset and equal in duration to the CS. A ratio of 0.0 indicates that the CS response rate was equal to the control rate. On the other hand, a ratio of +1.0 or -1.0 indicates, respectively, a 100% increase over the control rate during the CS,

or complete suppression of the response rate during the CS. Due to the variability in the response rates, no subject ever achieved a 100% response rate increase nor complete suppression for any experimental session. Although some CS presentations within a session were followed by complete suppression of responses, the mean inflection ratio, however, was quite a bit above the -1.0 level at the end of the session.

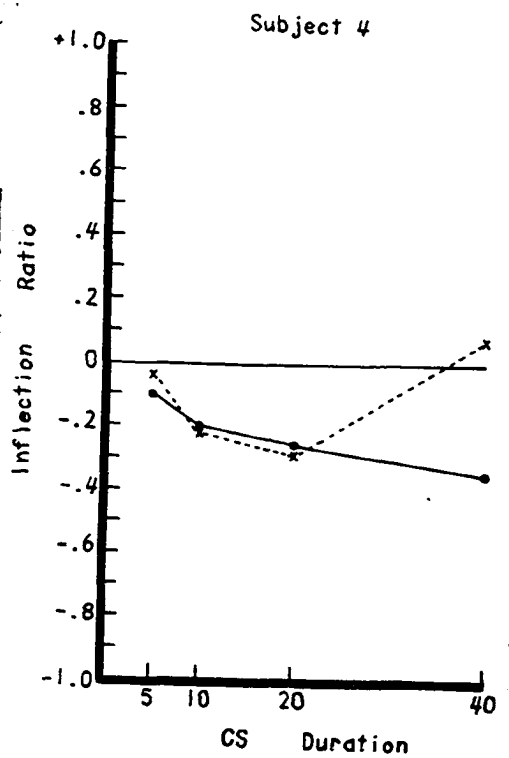
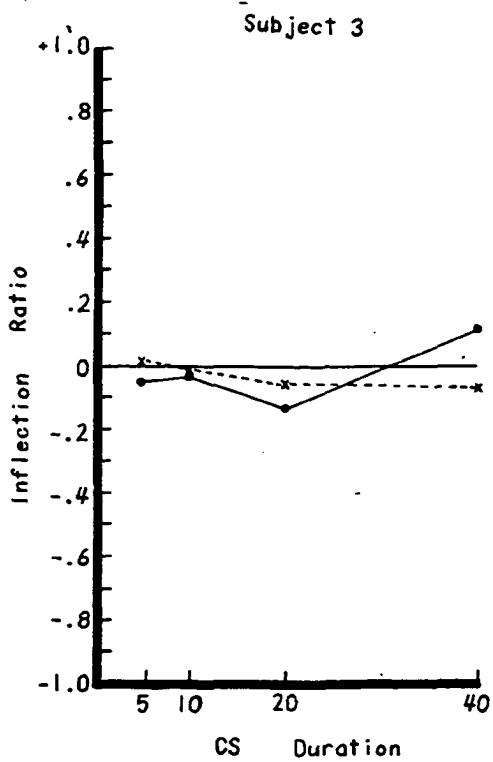
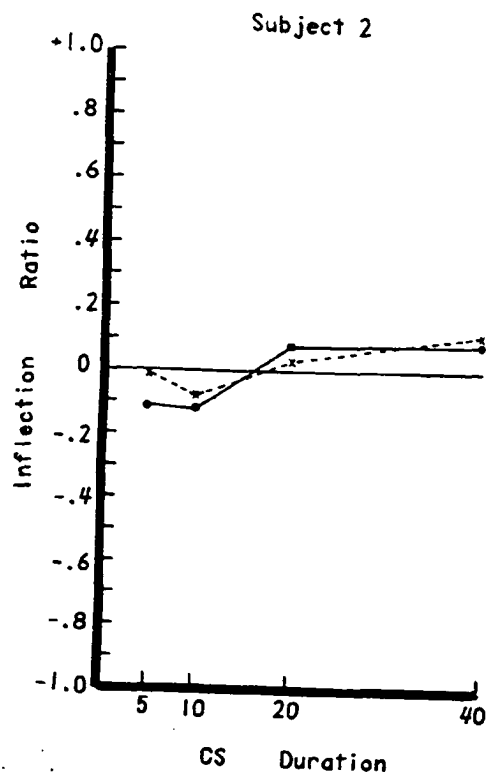
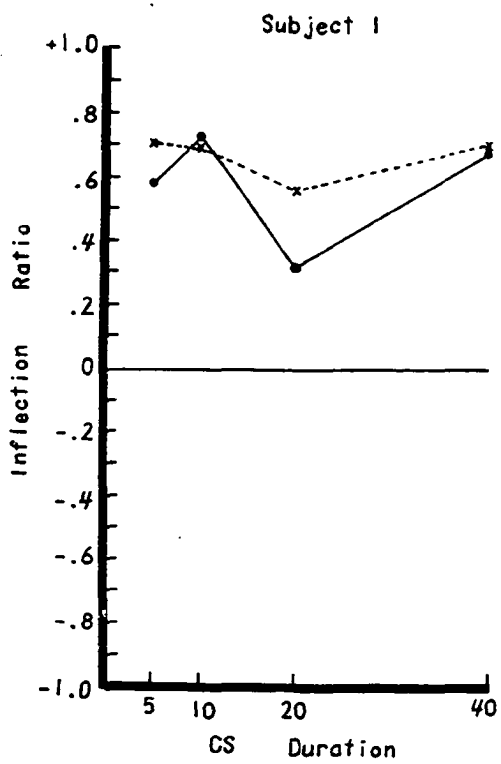
Figure 1 depicts the inflection ratios of each subject as a function of the duration of the conditioned stimulus. The mean inflection ratio for each of the two consecutive sessions are presented at each point. However, the 10 second CS duration was presented for a total of four sessions, therefore, the average inflection ratio is presented for that duration.

From Fig. 1, it is quite evident that subject #1 rather consistently exhibited the facilitation phenomenon over the four different CS durations. There was a sharp decline in the facilitation effect from the 5 to the 10 second CS, but, then, there was a slight upward trend from the 10 to the 20 to the 40 second CS durations. Thus, the least amount of behavioral disruption for subject #1 occurred during the 10 second CS. The greatest degree of variability in the response rate of subject #1 during the conditioned stimulus also occurred during the 10 second CS.

The remaining three subjects almost consistently exhibited conditioned suppression, although, on one occasion, subject #3 demonstrated a slight degree of facilitation. For subject #3, the greatest

Figure 1:

Inflection ratios of each subject as a function of
the duration of the conditioned stimulus.



variability in responding occurred during the 20 second CS trials, as was the case for subject #4. However, subject #2 tended to maintain a rather stable response rate over all four CS durations. There does not appear to be as obvious a trend in the responding of these subjects as there was for subject #1. Except for the data of subject #1, the changes observed in response rate as a function of CS duration appear to be minimal. The rate changes for subject #1, however, could possibly be closely related to the duration of the conditioned stimulus, but any conclusive data are lacking.

The data presented in Figure 2 represent the inflection ratio of each subject as a function of response rate for each of the ten experimental sessions. The mean rate of response for each subject was nearly proportional over the range of CS durations. However, there appears to be a relationship between the degree of facilitation and the subject's total response rate. It appears that the lower the overall response rate per session, the greater the tendency toward facilitation. This can be seen quite clearly in the record of subject #1. The converse of this can be seen in the record of subject #4. In this record, the higher the overall response rate, the less the tendency toward suppression. Although a correlation does appear to exist between degree of facilitation and/or suppression and response rate, there is the possibility that many of the changes in the inflection ratios could be due to individual differences.

On the cumulative record presented for subject #1, facilitation is represented by a nearly vertical line following CS presentation

Figure 2:

Inflection ratios of each subject as a function of the total number of responses emitted per experimental session.

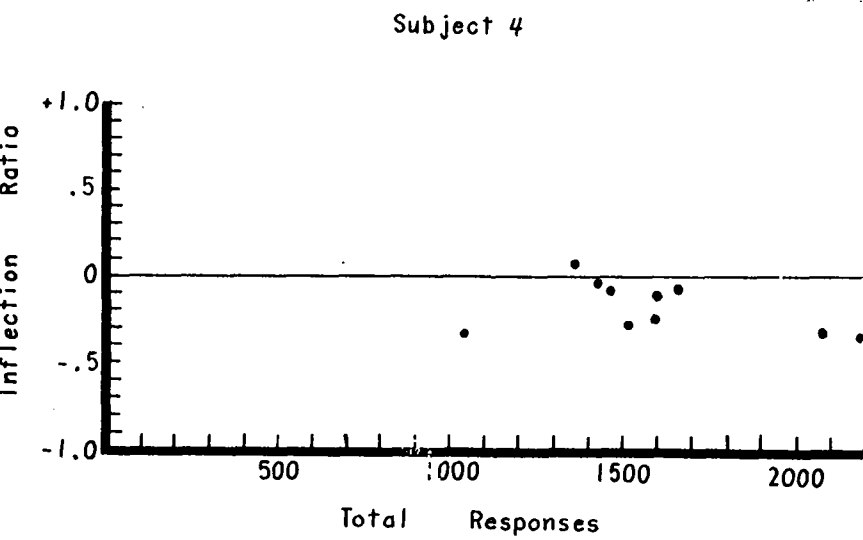
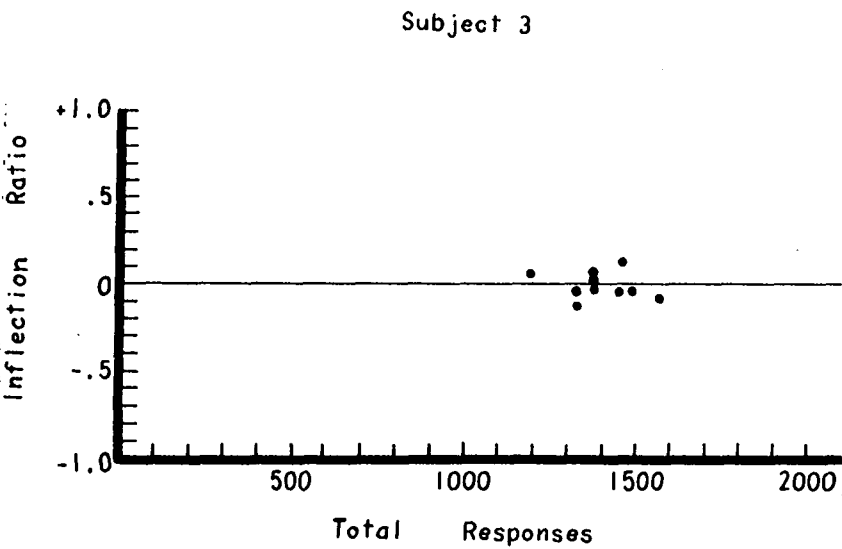
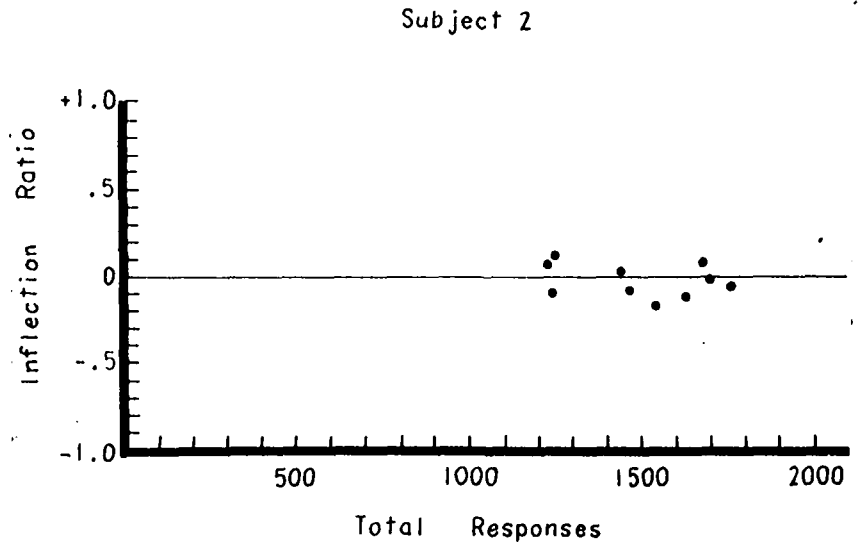
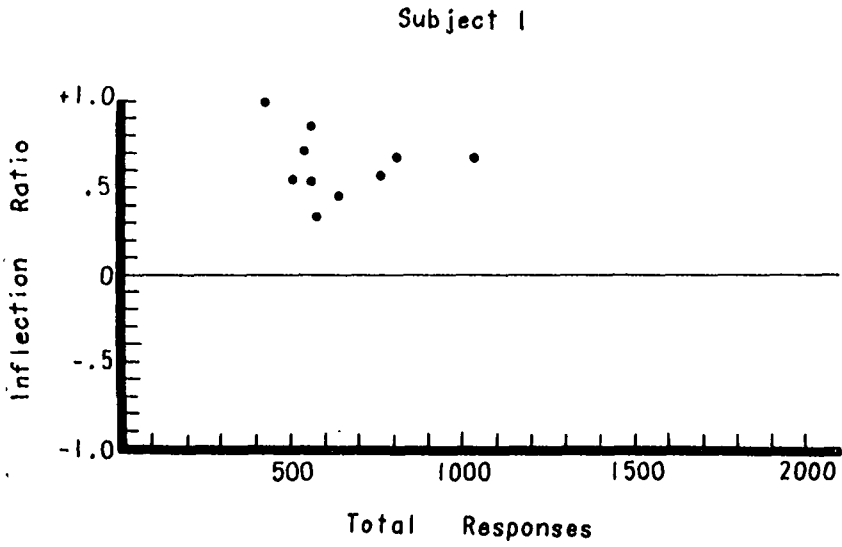
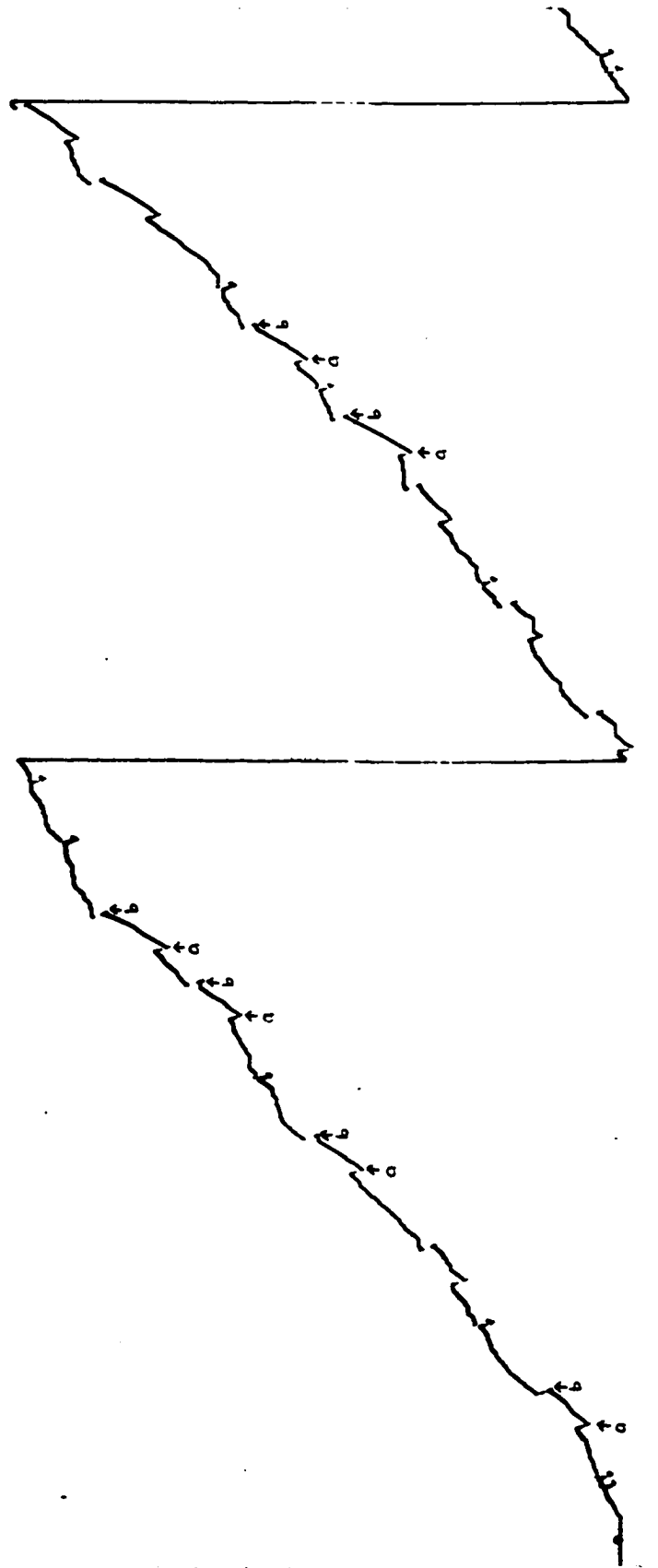


Figure 3:

Segment of a cumulative record for subject #1 during a presentation
of the 40 second CS.



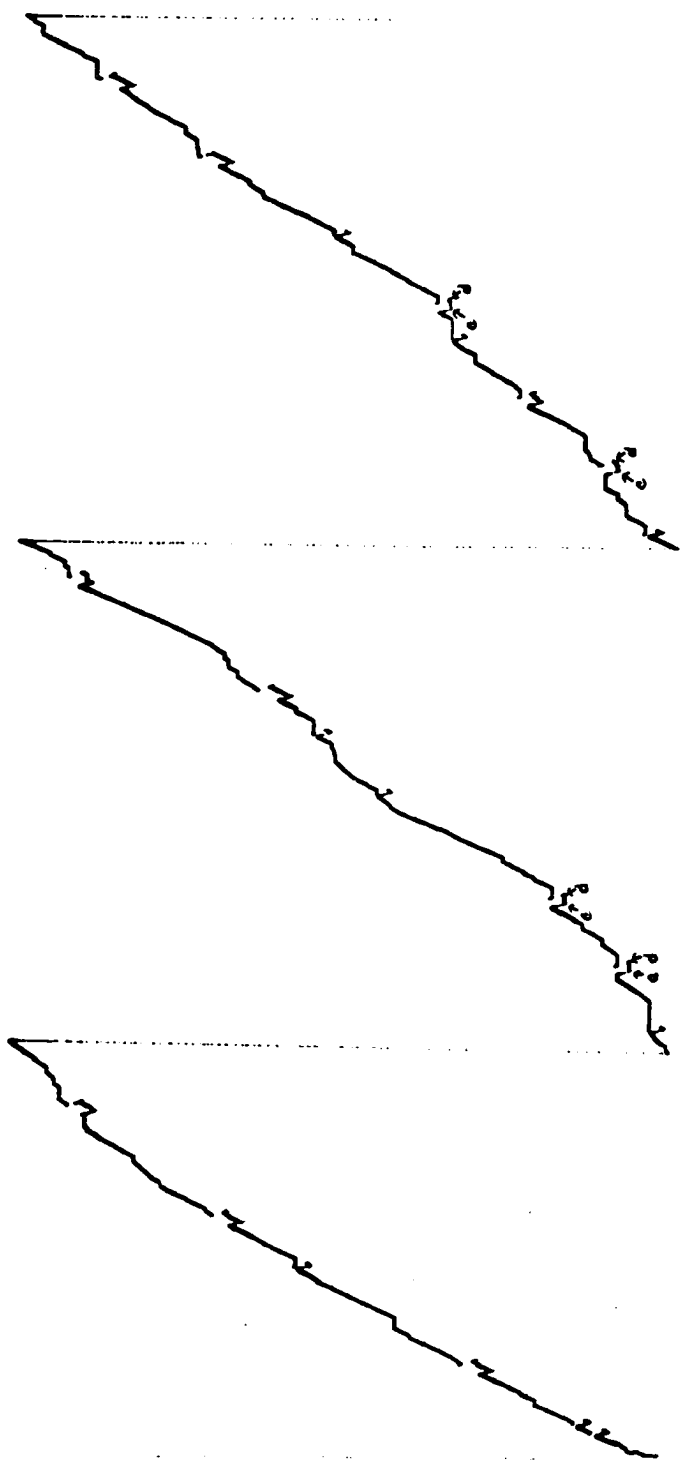
(line segment a to b; see Fig. 3). For subject #4, however, suppression is represented by a horizontal line following the presentation of the CS (line segment c to d; see Fig. 4). The presentation of the CS is indicated by a downward movement of the response pen until the CS is terminated, in which case the pen moves upward again. Response contingent reinforcement is indicated by a downward "pip" of the response pen.

The problem of variability in subjects' responding is demonstrated quite clearly in Fig. 3. Although subject #1 generally exhibited facilitation, there were occasions when suppression occurred during the conditioned stimulus. This fact, then, tends to distort some of the inflection ratios presented in Fig. 1 above.

Response variability is also evident for subject #4 in Fig. 2. No doubt, similar variables affecting the response rate of subject #1 were also operative in the rate of subject #4.

Figure 4:

Segment of a cumulative record for subject #4 during a presentation
of the 10 second CS.



DISCUSSION

In general, both the conditioned enhancement and suppression phenomena occurred during the stimulus that terminated with non-contingent positive reinforcement. This fact clearly demonstrates that a positive unconditioned stimulus will not always accelerate an operant behavior in a Pavlovian paradigm. The procedure employed in the present study was similar to that used in conditioned suppression studies (Estes and Skinner, 1941; Brady and Hunt, 1955; Annau and Kamin, 1961), with similar disruptive results. Thus, one could conclude that both phenomena are "characteristic of unconditioned stimuli generally whether they are positive reinforcers or aversive stimuli" (Azrin and Hake, 1969). The results of the present study support the view that emotional behavior is not necessarily the effect of anxiety-producing stimuli.

Most of the studies of "emotional" behavior that have been conducted to date have made extensive use of infra-human organisms as subjects, and have studied only the conditioned suppression phenomenon. A review of relevant experimental literature reveals the tremendous lack of research of emotional behavior with human beings as subjects (Watson and Raynor, 1920; Kanfer, 1958a; 1958b; Mulder, Lyon, and Pott, 1967; Mulder, 1967). These studies, to some extent, have demonstrated suppression with human subjects, using aversive events, and now, in the present study, suppression and facilitation using positively reinforcing events with humans. It may be, then, that data obtained from infra-human research have relevance for

understanding human behavior since it appears that certain variables found to be operative with animals may also be involved in human emotional behavior.

Superstitious conditioning as a determinant of facilitation.

One explanation for an increased response rate during a conditioned stimulus is that of superstitious conditioning (Herrnstein and Morse, 1957). In such a situation, it is believed that the non-contingent reinforcement is at some point presented contiguous to the occurrence of the operant response, thus increasing the response rate. Once the response rate has been increased, the response-reinforcement contiguity becomes more probable. Consequently, a point is reached at which the difference between response dependent and "free" reinforcement is negligible and superstitious behavior develops. Herrnstein and Morse employed a schedule of differential reinforcement for low rates (DRL), a fact which may be the basis for their interpretation of facilitation.

A review of the data for the present study shows that the superstitious conditioning explanation is not totally invalid because it was not possible to avoid any adventitious correlations between the lever pulling response and the "free" reinforcement. Except in the instances where the subject suppressed responding until after the termination of the buzzer and the delivery of the reinforcement, a superstitious explanation is admissible. However, superstitious conditioning is tenable only in so far as it relates to later instances of increased response rate and not to the initial occurrence

of increased rate. The question is, then, what in the present study would account for the very first instance of an increased rate during the CS? Unfortunately, the results of this study offer no acceptable explanation for the observed rate change. Each subject demonstrated that they had become completely adapted to the presentation of the buzzer before the CS-UCS trials were begun. This fact, therefore, tends to refute the idea of the subjects not being "used to" the buzzer and that this was responsible for the rate change.

Experimental design as a determinant of facilitation.

Unlike the studies of Estes (1943 and 1948), the CS-UCS pairings of the present study were always maintained concurrently with the operant reinforcement procedure. Estes employed a procedure in which he initially reinforced animals for lever pressing on a fixed interval (FI) schedule. Later, he removed the lever and presented the CS-UCS "free" reinforcement trials. Finally, after reinstating the lever and extinguishing the operant response, Estes found that the animals would respond at a higher rate during the presentation of the stimulus that had preceded food. The data of the present study suggest that the basic experimental conditioning procedure, in relation to the operant reinforcement procedure, does not appear to affect the results obtained.

Pliskoff (1961) observed suppression in animals during a stimulus that preceded a period of high reinforcement frequency using an experimental design similar to the one employed in the present study. This fact, too, would tend to make one wonder if the basic

experimental design, or arrangement of behavioral consequences, is an important factor in the analysis of emotional behavior, particularly since, in the present study, both facilitation and suppression were evidenced in a design that had previously been shown to yield only conditioned enhancement (Herrnstein and Morse, 1957.)

Response rate as a determinant of facilitation.

Probably the most appropriate explanation for the accelerated response rate can be found in the overall number of responses made by each subject during the experimental sessions. From the data, it appears that the higher the total number of responses per session the greater the tendency for facilitation not to occur. For example, the total number of responses for subject #1 typically ranged between 400 and 800 per experimental session. Also subject #1 showed the facilitation phenomenon most consistently. On the other hand, subject #4 maintained a fairly high rate of responding with a range between 1000 and 2000 responses per session. This subject, however, tended to exhibit the suppression phenomenon. There were varying degrees of suppression and facilitation exhibited by subject #2 and subject #3, and they too had response rates that ranged between 1100 and 1700 per session. Conditioned suppression studies by Blackman (1966) tend to confirm any suspected correlation between baseline response rate and facilitation or suppression. He found that, when frequency of reinforcement was controlled, there was a definite positive correlation between high response rate and severe conditioned suppression. In relating these findings to

the present study, it may be that the degree of conditioned suppression or facilitation obtained was directly related to the baseline response rates of the subjects. At any rate, it may be an important factor to analyze in later research.

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