Response Rate, Latency, and Resistance to Change

Stephen Joseph Fath

Western Michigan University

Follow this and additional works at: https://scholarworks.wmich.edu/dissertations

Part of the Experimental Analysis of Behavior Commons

Recommended Citation
https://scholarworks.wmich.edu/dissertations/2589

This Dissertation-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Dissertations by an authorized administrator of ScholarWorks at WMU. For more information, please contact maira.bundza@wmich.edu.
RESPONSE RATE, LATENCY, AND RESISTANCE TO CHANGE

by

Stephen Joseph Fath

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Doctor of Philosophy
Department of Psychology

Western Michigan University
Kalamazoo, Michigan
April 1981
RESPONSE RATE, LATENCY, AND RESISTANCE TO CHANGE

Stephen Joseph Fath, Ph.D.
Western Michigan University, 1981

Response rate has been criticized as an adequate measure of response strength on the basis that rate reflects the adventitious reinforcement of interresponse times. Nevin (1974, 1979) proposed relative resistance to change as an alternative measure. Nevin (1974) employed multiple-pacing schedules in which either high- or low-rate requirements were placed in tandem with either VI 1 min or VI 3 min schedules of reinforcement. The results suggested that low-rate responding may be more resistant to change when schedules are equated for reinforcement frequency. Fath and Malott (1979) replicated Nevin's experiment, but found no evidence that contingencies on response rate affect relative resistance to change. That Nevin observed differences in response strength under similar conditions in his study, may be due to differences in the programming of high- and low-response rate contingencies. In the present study, refinements of the procedure used by Nevin (1974) and Fath and Malott (1979) were used, and a parametric investigation of the effects of response-independent food on behavior maintained by a multiple-pacing schedule was conducted. The results support the findings of Fath and Malott (1979), that response rate contingencies do not affect relative resistance to change. Both response rates and latencies to respond varied systematically with increases in the magnitude of response-independent food presentations. Response rates decreased, while latencies increased. These results
are consistent with Nevin's suggestion that relative resistance to change is a function of reinforcement frequency, but not with the notion that response rate contingencies affect response strength. The relation between Nevin's concept of response strength and previous experimental findings is discussed.
ACKNOWLEDGEMENTS

I would like to thank Drs. M. Kay Malott, John L. Michael, David O. Lyon and Arthur G. Snapper for their guidance, expertise, and friendship during the course of my graduate studies. In addition, thanks are due Dr. Clarence Goodnight for serving as the outside member of my dissertation committee, and to Deborah Grossett for assistance in programming and conducting the early part of this investigation. I would also like to thank the Department of Psychology and The Graduate College for their support, without which this study would not have been possible.

Stephen Joseph Fath
INFORMATION TO USERS

This was produced from a copy of a document sent to us for microfilming. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help you understand markings or notations which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure you of complete continuity.

2. When an image on the film is obliterated with a round black mark it is an indication that the film inspector noticed either blurred copy because of movement during exposure, or duplicate copy. Unless we meant to delete copyrighted materials that should not have been filmed, you will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed the photographer has followed a definite method in "sectioning" the material. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For any illustrations that cannot be reproduced satisfactorily by xerography, photographic prints can be purchased at additional cost and tipped into your xerographic copy. Requests can be made to our Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases we have filmed the best available copy.

University Microfilms International
300 N. ZEEB ROAD, ANN ARBOR, MI 48106
18 BEDFORD ROW, LONDON WC1R 4EJ, ENGLAND
PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark √.

1. Glossy photographs or pages ______
2. Colored illustrations, paper or print ______
3. Photographs with dark background ______
4. Illustrations are poor copy ______
5. Pages with black marks, not original copy ______
6. Print shows through as there is text on both sides of page ______
7. Indistinct, broken or small print on several pages ______
8. Print exceeds margin requirements ______
9. Tightly bound copy with print lost in spine ______
10. Computer printout pages with indistinct print ______
11. Page(s) ___________ lacking when material received, and not available from school or author.
12. Page(s) ___________ seem to be missing in numbering only as text follows.
13. Two pages numbered ___________. Text follows.
14. Curling and wrinkled pages ______
15. Other ____________________________________________________________________
# TABLE OF CONTENTS

ACKNOWLEDGEMENTS ................................................................. i

LIST OF FIGURES .................................................................... iv

Chapter

I.  INTRODUCTION ...................................................................................... 1

II.  METHOD ............................................................................................... 15

Subjects ....................................................................................... 15

Apparatus ..................................................................................... 15

Procedure ...................................................................................... 16

Magazine training ......................................................................... 16

Keypeck training ........................................................................ 16

Baseline schedules ..................................................................... 17

Testing .......................................................................................... 22

III. RESULTS ............................................................................................. 24

Baseline Assessment ................................................................... 24

Effects of Response-Independent Food .................................. 28

IV. DISCUSSION ....................................................................................... 44

BIBLIOGRAPHY .................................................................................. 54
LIST OF FIGURES

Figure 1. State diagram of contingencies on response rate used by Nevin (1974) and Fath and Malott (1979)................................. 1

Figure 2. State diagram of terminal baseline procedure..............18

Figure 3. Mean inter-response time per opportunity as a function of IRT in seconds for individual subjects........................................25

Figure 4. Mean response rate and mean latency as a function of response-independent food magnitude in seconds for individual subjects...........30

Figure 5. Mean response rate and mean latency as a function of response-independent food magnitude in seconds for individual subjects...........33

Figure 6. Latency as a function of trials within sessions of response-independent food presentation (Subjects 1 and 2)..................37

Figure 7. Latency as a function of trials within sessions of response-independent food presentation (Subjects 3 and 4)..................39

Figure 8. Latency as a function of trials within sessions of response-independent food presentation (Subjects 5 and 6)...............41
INTRODUCTION

In the field of operant conditioning, reinforcement is defined as the presentation of an event following a response, which increases the future probability, or rate, of the response. It is often stated that reinforcement increases the strength of a response (cf. Herrnstein, 1970; Smith, 1974). The term "response strength" implies that several properties of behavior covary. Each property is taken as a measure of strength, but no one property is synonymous with this quality of behavior. Although the notion of response strength has appeared in the literature since the early days of reflexology (Whytt, 1751; Sechenov, 1863; Sherrington, 1906; Pavlov, 1927; Thorndike, 1911; and Hull, 1943), no one method of assessing the strength of a response has come into common usage. Response rate, latency, amplitude, and resistance to extinction have all failed to gain general support because orderly data with quantitative and general significance have not been forthcoming (Herrnstein, 1970).

Skinner (1938) noted that there are two effects of reinforcement; one is the immediate increase in response rate, the second is increased resistance to extinction with the use of additional reinforcers. He noted, however, that these two measures, response rate and resistance to extinction, are not well correlated, and settled on response rate as his measure of response strength.

The lack of correlation between response rate and resistance to extinction is exemplified in a study by Wilson (1954) involving fixed-interval (FI) reinforcement schedules. Wilson trained different groups of rats at different FI values, and obtained a decreasing
monotonic function relating average response rates to the length of the fixed-interval. When the subjects were exposed to an extinction procedure, a non-monotonic relationship between the mean number of responses during extinction and the value of the FI schedule employed during training was found; maximum responding was observed at an FI value of one minute.

Response rate does not appear to be a good general measure of response strength. Such independent variables as magnitude and delay of reinforcement have been shown to have little effect on response rate (Catania, 1963; Neuringer, 1967; Richards, 1973). Rate of response may also be insensitive to rate of reinforcement, especially at high reinforcement rates (Catania and Reynolds, 1968). More importantly, however, response rate may be both increased by reinforcement rate and shaped by the contingencies which relate responding to reinforcement (Morse, 1966). As such, response rate cannot be interpreted unambiguously in relation to the concept of strength (Nevin, 1977, 1979).

Moderate response rates may be maintained on interval schedules because they selectively reinforce long inter-response times (IRTs) (see Shimp, 1974). In ratio schedules, however, high response rates may be maintained because they lead to higher average rates of reinforcement. Although the strengthening effect of reinforcement presumably operates in the same way under all schedules, the strengthening and rate-shaping effects cannot be easily disentangled.

The objection stated above is that the role of the distribution of reinforced IRTs in determining response rate is neglected. The mean rate of response is the reciprocal of the mean of the distribution of
IRTs, which is in turn determined by the distribution of reinforcement for those IRTs. The suggestion is that a subject's IRTs are distributed according to the frequency with which each is reinforced relative to the others. From this perspective, the basic response unit includes the pauses between successive responses, rather than the simple switch closure. The point is that response rate is a conditionable dimension of behavior. That is, contingencies on response rate, scheduled or spurious, can result in a biased dependent variable. This contention is supported by numerous studies (cf. Anger, 1956, 1973; Blough, 1963; Blough and Blough, 1968; Malott and Cumming, 1965; Shimp, 1967, 1968; Staddon, 1968; Williams, 1968; and Wilkie and Pear, 1972).

Nevin (1974, 1977, 1979) has suggested that a concept of response strength, phrased in terms of resistance to change, may be used to summarize the effects of diverse procedures. Changes in response rates, relative to their own baselines, are observed when some operation is used to disrupt ongoing responding. Under this procedure, two, or more, performances are compared under identical conditions that disrupt at least one of them. It is then possible to make ordinal comparisons. A convenient way to arrange this state of affairs is through the use of a multiple schedule in which different reinforcement schedules, each correlated with distinctive stimuli, are presented successively. In this way it is possible to assess the effects of a third variable on individual performances. Examples of the disruptive operation include manipulations of deprivation schedules or the introduction of response-independent food.
In a series of experiments by Nevin (1974), pigeons were trained with one schedule of food reinforcement for pecking in the presence of a lighted response key associated with one component of a three-component multiple schedule, and a different schedule in the presence of a second key color. After responding in both schedule components stabilized, response-independent food was presented in the presence of an unilluminated key which intervened between color components. The response rates, relative to their own baselines, in both schedule components decreased as a function of response-independent food frequency during dark-key periods. The relative decreases in responding were related to the frequency, delay, or magnitude of reinforcement associated with each component, as well as to response rate-contingencies. Nevin (1979) provides an elaboration, and additional evidence, which suggests the utility of a concept of response strength based on resistance to change.

Experiment I of Nevin's (1974) study was designed to show changes in response rate during a three-component multiple schedule where pecking was reinforced with food at different constant frequencies, while the frequency of response-independent food in the third component was varied systematically. The results were consistent with the common finding that responding in one schedule component depends on the relative frequency of reinforcement produced by responding in that component, and that the source of reinforcement and the contingencies in the other component do not alter that relationship (Herrnstein, 1961, 1970, 1973; Nevin, 1968; Rachlin and Baum, 1972). In Experiment I, the relative reinforcement rate was always higher.
in the presence of a green stimulus, and relative response rate was less affected by the introduction of response-independent food.

It has already been noted that the evaluation of response strength is complicated by the fact that response rate is a conditionable dimension of behavior, and that the schedule employed in conditioning response rate may have the effect of establishing qualitatively different performances which cannot be easily ordered with respect to strength. Experiment V of Nevin's (1974) study evaluated the possibility that response strength may be meaningful only where performances maintained by similar contingencies are compared. As in Experiment I, described above, a three-component multiple schedule was used. Red and green keylight presentations, each of 60 sec duration, were initially correlated with variable-interval (VI) 1 min or VI 3 min schedules of reinforcement. The schedule components alternated regularly with 30-sec dark-key periods intervening. Dark-key periods were correlated with extinction during the baseline phase of the experiment. Next, contingencies on the rate of response necessary to collect reinforcement were placed in tandem with the VI schedule requirements. In a tandem schedule, two contingencies must be met successively in order to collect a scheduled reinforcer. No stimulus changes are differentially correlated with the different components of the reinforcement schedule in a tandem arrangement. A differential-reinforcement-of-low-rate (DRL) contingency was placed in tandem with either the VI 1 min or VI 3 min schedule, and a differential-reinforcement-of-high-rate (DRH) requirement was placed in tandem with the other VI schedule. The entire arrangement described here is called a "multiple-pacing schedule" of reinforcement.
Figure 1 is a State Diagram (Snapper, Knapp and Kushner, 1970) which illustrates the essentials of the terminal baseline contingencies of reinforcement. The figure is organized in terms of "state sets," which describe portions of the experimental procedure, and "states," (S#) which are defined by the stimulus conditions and response contingencies active at a given moment in the experimental environment. Requirements for transition from one state to another appear on the transition vectors (arrows). The two state sets depicted in Figure 1 are, of course, mutually exclusive, since a multiple schedule was employed. Only one set of contingencies was in effect at a given moment.

The upper portion of Figure 1 describes the tandem VI, DRL contingency employed by Nevin (1974, Exp V) and Fath and Malott (1979) in their replication of Nevin's procedure. At the onset of each red stimulus component, an independent VI timer began timing (S2). After the timer had timed-out, subjects were required to make a response (S3), wait at least three sec (S4), and then emit a second response (S5) in order to collect reinforcement. Responses which were emitted prior to the timing-out of the three sec timer in S4 reset the timer. In this way, only responses terminating IRTs of at least three sec were reinforced. Reinforcements not collected at the end of this component were cancelled.

The lower portion of Figure 1 depicts the tandem VI, DRH contingency used in both experiments, in the presence of a green keylight. An independent VI timer was activated at the time of component onset (S2). Once the VI timer has timed-out, subjects were required to emit three responses within three sec (S3) in order to collect reinforcement.
Figure 1. State diagram of contingencies on response rate used by Nevin (1974) and Fath and Malott (1979).
Figure 1

**TANDEM VI, DRL**

![Diagram of TANDEM VI, DRL component offset]

**TANDEM VI, DRE**

![Diagram of TANDEM VI, DRE component offset]

NEVIN, 1974, Exp. V.
PATH AND MALOTT, 1979
There were no specific IRT requirements on these responses. In other words, reinforcement was presented no matter what the particular IRTs, so long as the ratio of three responses was completed before the three sec timer (S3) had timed-out. If the reinforcer were not collected within the specified time limit, it was cancelled.

For both the red and green components, the next VI began timing after reinforcement delivery (S6 for DRL and S4 for DRH) provided that the same stimulus was active. If either schedule component had timed-out during the course of reinforcement delivery, the food presentation was not interrupted, rather the state set was deactivated following reinforcement delivery. Component offset prior to the completion of the response rate contingencies resulted in the loss of reinforcement in the case of both contingencies.

Nevin used two values of the independent variable, rate of response-independent food presentation during dark-key periods (60 or 360 per hour), to assess differential resistance to change. The first exposure to 60 response-independent food presentations per hour lasted for 14 sessions. Thereafter, presentations were limited to one session (The obtained rates of reinforcement changed substantially under the scheduled contingencies, and Nevin regarded these data as uninterpretable). Following the second test (360 response-independent food presentations per hour), baselines were recovered, and then extinguished by withholding food reinforcement for seven sessions. The baseline conditions were then reversed. That is, if the DRL contingency had been in tandem with the VI 1 min schedule, it was placed in tandem with the VI 3 min schedule, and the DRH contingency was placed in tandem with the other VI schedule. Baselines were then established for the next series of
test sessions with response-independent food.

Nevin's dependent variable was relative response rate. In this case, the observed response rate for each component during test sessions was expressed as a proportion of its associated baseline response rate. Baseline response rates were established by averaging the data for each component across the three sessions prior to each test session.

The data from Nevin's (1974, Exp V) study suggest that when contingencies on response rate are the same (DRL or DRH), performances maintained by VI 1 min reinforcement are stronger (less changed from baseline) than those maintained by VI 3 min reinforcement. In addition, the data for at least two subjects provided some suggestion that performances maintained by the DRL contingency are stronger than those maintained under the DRH contingency. However, because these results were unexpected, the experiment was not designed to isolate the effects of the DRL and DRH contingencies. Nevin stated that to do so, it would be best to arrange identical reinforcement frequencies in conjunction with the different response rate contingencies in the two color components of a multiple schedule. This arrangement would allow comparison of the effects of the response rate contingencies without the variability introduced by the intervals of nearly three months which elapsed between comparisons in his study. Nevertheless, Nevin stated that his results, although permitting only weak conclusions, in conjunction with those of others (Blackman, 1968), indicate that high-rate requirements generate weaker performances than low-rate requirements.

Fath and Malott (1979) provided systematic replication of Nevin's
(1974, Exp V) procedure. In order to allow for the appropriate comparisons of the effects of high- and low-rate contingencies, as suggested by Nevin, two subjects were exposed to a Multiple VI 1 min, DRL/VI 1 min, DRH condition, and two subjects were exposed to the same differential-rate contingencies in tandem with VI 3 min schedules of reinforcement. In addition, four subjects were exposed to the conditions employed by Nevin.

The results of Fath and Malott (1979) support Nevin's (1974, 1977, 1979) findings that reinforcement frequency is a strong determinant of relative resistance to change, regardless of the observed baseline response rates. However, Nevin's (1974) tentative conclusion, that contingencies on response rate affect resistance to change, was neither confirmed nor disconfirmed. The average results for the pigeons exposed to those conditions employed by Nevin (1974, Exp V) showed similar effects. However, when the schedule components were equated for reinforcement frequency, there were no consistent differences between responding maintained under the DRL and DRH contingencies.

Nevin (1974, 1977, 1979) has demonstrated that relative resistance to change is a viable response measure which varies in a consistent manner with various parameters of reinforcement (e.g. frequency and delay). To the extent which this is true, the associated concept of response strength is supported as potentially useful. Fath and Malott (1979) confirmed Nevin's approach to the quantification of response strength by demonstrating that relative resistance to change varies with reinforcement frequency in the expected manner.

The failure to support the suggestion that low- and high-rate
requirements produce differences in resistance to change, of course, in no way invalidates Nevin's approach to the quantification of response strength; rather the finding suggest that such contingencies on the temporal distribution, and number, of responses have little or no effect on resistance to change. That Nevin observed differences in strength between behaviors maintained by high- and low-rate contingencies, which led him to the tentative conclusion that such performances are qualitatively different, may be attributed to differences in the programming of the response rate contingencies, which differentially affected the availability of reinforcement for high- and low-rate behaviors.

Inspection of Figure 1 suggests that the contingencies used by Nevin (1974, Exp V) and Fath and Malott (1979) are essentially inequivalent with respect to the disposition of uncollected reinforcers. Reinforcement for DRL responding was not cancelled until the end of a given schedule component, but that for DRH responding was cancelled within three sec of set-up, unless the subject emitted the appropriate number of responses within the specified time limit. In addition, the DRL contingency is open-ended. Any IRT of three or more seconds duration can be reinforced under this procedure. The net effect of these differences is on the availability of reinforcement for responses which occur during the course of testing. The programming of rate contingencies in the manner described in Figure 1 creates a bias in favor of responding maintained by the DRL contingency. A subject stands a better chance of being reinforced even after long pauses in responding under this condition, whereas under the DRH contingency
reinforcement is not likely unless the animal is responding as the VI timer reaches the end of its cycle. Long pauses result in a decreased likelihood of reinforcement. When reinforcement is more likely in one condition than in another, more responding, and thus greater resistance to change, is to be expected.

When the rate of reinforcement is held constant, the rate at which responding occurs can be altered by placing contingencies on response rate in tandem with the schedule of reinforcement. Since response rate is conditionable in this way, there is, as Nevin (1979) points out, little sense in identifying response strength with response rate. Rather, the question of whether differential reinforcement of response rates establishes performances which differ in resistance to change becomes meaningful. As yet, a clear answer to this question has not been forthcoming. The methods which have been used to establish different response rates while holding reinforcement rates constant are inequivalent. When the contingencies of reinforcement are not equivalent, it is safe to assume that the performances which they maintain will differ.

In the following experiment, six pigeons are exposed to an alternative set of contingencies which is designed to reduce the differences discussed above. Under this procedure, only responses which terminate IRTs which fall within specific bandwidths are reinforced. For example, in order to collect a scheduled reinforcer, the subject must emit a response which terminates an IRT of at least 2.5 sec, but no longer than 3.5 seconds (2.5 sec \( \leq \) IRT \( \leq \) 3.5 sec). Responses which terminate shorter IRTs reset the timer associated with the lower limit of the required IRT, while those which are longer...
result in recycling to ensure that reinforcement is presented only for responses which terminate the appropriate IRTs. In addition, reinforcement, once available, remains set-up until it is collected. Thus, during testing reinforcement is available for appropriate patterns of response despite the fact that long pauses may occur.
METHOD

Subjects

Six naive, barren-hen White Carneaux pigeons, approximately seven years old at the beginning of the study, served as subjects. The birds were obtained from the Palmetto Pigeon Plant, Sumter, South Carolina. The subjects were maintained at 80%, ± 5%, of their free-feeding weights, and were allowed free access to grit and water in their home cages throughout the experiment.

Apparatus

Three, two-key Lehigh Valley Electronics pigeon testing chambers were used. The intelligence panel in each chamber was approximately 32.5 cm square, with the removable floor in place. The response keys, translucent panels behind 2.5 cm diameter holes, were located 23 cm from the bottom of the intelligence panel and 8.8 cm from either edge. The right key remained unilluminated and inoperative throughout the experiment. A minimum force of 0.2 N was required to operate the key, which was illuminated from behind by an Industrial Electronics Engineers, one-plane readout projector. Kodak wratten filters were used to provide red and green stimuli. Access to grain was through a 5 cm by 6 cm opening centered on the intelligence panel 11 cm above the chamber floor. The grain aperture was illuminated by a General Electric #1819 bulb whenever the feeder was operated. Chamber illumination was provided by a 7.5 watt General Electric bulb centered on the intelligence panel 5.5 cm above the response keys. The houselight remained illuminated throughout the daily sessions.
White noise was provided through use of a Grason-Stadler, Model 901-B white noise generator connected to a 7.5 cm speaker located 13.5 cm from the chamber floor, and 5 cm from the right edge of the intelligence panel. The three chambers were interfaced (State Systems, Inc, Kalamazoo, MI) with a PDP 8-f (Digital Equipment Corp, Maynard, MA) mini-computer, located in an adjacent room. Scheduling of stimulus events, reinforcement contingencies, and data collection were accomplished through use of Time-Share SuperSked software (State Systems, Inc).

Procedure

Magazine training. During the first session, the subjects were trained to eat from the food hopper. Each bird was manually held in position in front of the operated magazine until it ate for approximately 3 sec, at which time the hopper was lowered for a period of about 15 seconds. This procedure was repeated until the subject ate from the hopper five times in succession. The chamber was then closed, and an automatic program started. The remainder of the magazine training session consisted of 30 five-sec hopper presentations which occurred on a Variable Time (VT) 1 min schedule. The houselights and white noise were both turned on during this training session, but the response key remained unilluminated.

Keypeck training. During the next three sessions, the subjects were exposed to a non-differential autoshaping procedure, in which eight-sec presentations of either the red or the green keylight were followed by five-sec response-independent food presentations. These events were scheduled to occur on a VT 1 min schedule. The initial stimulus color for each of these sessions was selected randomly. Thereafter, the
red and green stimuli alternated regularly on a trial-by-trial basis until 40 food presentations had been made.

Baseline schedules. After the third session under the autoshaping procedure, the procedure was changed to a response-contingent arrangement. Variable Interval 1 min (VI 1 min) schedules were associated with each of the two key colors. This initial procedure is best described as a Multiple Variable Interval/Extinction/Variable Interval (MULT VI/EXT/VI) schedule of reinforcement. The duration of each VI schedule component was 60 seconds. The extinction schedule was correlated with a dark response-key, presentations of which lasted 30 seconds. The interval values for the VI schedules were selected randomly within each session from independent arithmetic series associated with each stimulus condition. As in the autoshaping procedure described above, the selection of the initial stimulus color was random following the first dark-key period. Thereafter, the VI schedule components alternated regularly with dark-key periods intervening. Sessions terminated following the fortieth VI schedule component.

Contingencies on the rate of response necessary to collect a scheduled reinforcer were introduced in the fifty-first session. Figure 2 is a State Diagram of the terminal baseline procedure. Recall that a state (S#) is defined by the stimulus conditions and response contingencies active at a given moment in the experimental environment. Requirements for transition from one state to another appear on the transition vectors (arrows) along with any stimulus changes correlated with the transition requirement. A state set (S.S.#) represents a collection of conditions which describe all, or a portion.
Figure 2. State Diagram of the terminal baseline procedure.
Figure 2

3.3.1/ Stimulus Alternation

3.3.2/ Tandem VI 1 min, 2.5° < E < 3.5° (Red Component)

3.3.3/ Tandem VI 1 min, 0.5° < E < 1.5° (Green Component)

3.3.4/ Session Timing

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
of, the experimental procedure.

In Figure 2, parallel state sets are used to describe the stimulus conditions (S.S. 1) and their associated reinforcement contingencies (S.S. 2 and S.S. 3). As the term implies, operations in parallel state sets are usually, but not always, dependent upon conditions in other state sets. In order to synchronize the operations in parallel state sets, Z pulses are used. For example, when the red stimulus is turned on (S3 of S.S. 1), a Z1 pulse is produced as an output. The Z1 is used, in turn, as an input signal to activate S.S. 2, which controls the contingencies of reinforcement associated with the red keylight. Similarly, another Z1 is output when the component duration timer associated with the red stimulus times-out. This Z1 pulse de-activates State Set two. State Set three is active when the green stimulus light is turned on (S4 of S.S. 1), and S.S. 4 shows that the session is terminated following the fortieth schedule component presentation.

The red and green stimulus conditions were each correlated with a different tandem schedule of reinforcement. In a tandem schedule, as you will remember, two contingencies must be met successively in order to collect a reinforcer. No stimulus changes are differentially associated with the two components of the reinforcement schedule in a tandem arrangement. In the present procedure, two tandem schedules of reinforcement alternated regularly with 30-sec dark-key periods intervening. Throughout the baseline phase of the procedure, the dark-key remained correlated with an extinction (EXT) schedule.

The contingencies which were in effect in the presence of the red
stimulus (S3 of S.S. 1) are described in S.S. 2, and the contingencies associated with the green stimulus (S4 of S.S. 1) are described in S.S. 3. The criticism regarding the procedures of Nevin (1974, Exp V) and Fath and Malott (1979) which was raised in the introduction, is addressed by use of response rate contingencies in which subjects are reinforced for responses which terminate IRTs within specified bandwidths (T1" ≤ IRT ≤ T2"). The use of this contingency allows the experimenter to equate the high- and low-rate contingencies for the number of required responses. In addition, the contingencies employed in the present experiment include saving uncollected reinforcers across schedule components, thus equating the two schedules for the availability of reinforcement.

The contingencies which were in effect in the presence of the red stimulus are described in S.S. 2: When the red stimulus was turned on, an independent VI timer associated with that component (S3) began timing. After the interval had timed-out (S4), the subject was required to emit one response, wait at least 2.5 sec (S5), and then emit a second response (S6) within one sec in order to collect the scheduled reinforcer (S7). Responses which were emitted prior to the end of the required 2.5 sec pause reset the timer associated with S5. Failure to emit the second response within the one sec time limit reset the IRT requirement (return to S4). Once scheduled, reinforcement remained available until it was collected. If the 60-sec red component timer had timed out prior to reinforcement collection, the opportunity for reinforcement was saved (S8) until the next red stimulus appeared. When the next red stimulus was turned on, S4 of S.S. 2 was the
effective condition. The subject, once again, had to meet the IRT requirement in order to collect the scheduled reinforcer. This procedure constitutes variable-interval reinforcement for differentially-low-rates of response, in a tandem (TAND) schedule of reinforcement \((\text{TAND VI 1 min, } 2.5 \text{ sec} \leq \text{IRT} \leq 3.5 \text{ sec})\).

The procedure for variable-interval reinforcement for differentially-high-rates of responding \((\text{TAND VI 1 min, } 0.5 \text{ sec} \leq \text{IRT} \leq 1.5 \text{ sec})\) is described in S.S. 3 of Figure 2. The contingencies described in this portion of the State Diagram are essentially the same as those described above for the red stimulus component. State Set three, however, was active when the green stimulus was turned on (S4 of S.S. 1), and the required IRT was different. In this condition, once the VI timer had timed-out, the subject was required to wait only 0.5 sec (S5) before emitting a second response within one sec (S6). Note that, for the two schedule components, the required IRTs differ, but the bandwidths remained constant at one second.

**Testing.** After 50 sessions with the multiple-pacing schedules in effect, the testing phase of the experiment began. On test days, response-independent food presentations were made during dark-key periods. The onset of the response-independent food presentation always occurred 10 sec after the onset of the dark-key period. The duration of the hopper presentations was varied. Six levels of the independent variable (magnitude of response-independent food presentation) were used: 2.5 sec, 5.0 sec, 7.5 sec, 10.0 sec, 12.5 sec, and 15.0 sec. Magnitude of response-independent reinforcement, rather than frequency, was used, since in a previous experiment (Fath and Malott, 1979)
response-independent food presentations frequently overlapped the beginning of the subsequent schedule component. When this is the case, increased error would be expected in a latency measure.

Each test lasted for one session, and three tests were conducted at each level of the independent variable. Order of presentation for the different values of response-independent food presentation was randomized for each subject. A baseline recovery period of six days was allowed between each test session. During the first two days of this period, subjects remained in their home cages while their weights returned to the 80% deprivation level. Subsequently, the animals were returned to the baseline condition described above.
RESULTS

The data collected for each session included: the number of responses during dark-key periods, and during the red (2.5 sec ≤ IRT ≤ 3.5 sec) and green (0.5 sec ≤ IRT ≤ 1.5 sec) stimulus conditions, the number of scheduled and collected reinforcers for each component, trial-by-trial latency to respond in the presence of each stimulus, and inter-response times. Latencies were collected in 0.01 sec increments, and were measured from the onset of each component until the onset of the first response. If no response occurred in the presence of a given stimulus, a value of 60 sec, the component duration, was recorded in the counter associated with that particular trial. Inter-response times were collected in one-hundred and one, 0.1 sec bins. The one-hundred and first bin was the "dump" bin, and contained all IRTs greater than 10 sec. The same data were collected for all test sessions.

Baseline Assessment

In Figure 3, mean inter-response time per opportunity (IRT/OP) is shown as a function of IRT in seconds. Inter-response time per opportunity is a statistic which estimates the probability of a response given the passage of time since the previous response (Wilcoxin, 1949; Anger, 1956, 1973). The IRT/OP statistic is calculated by dividing the number of IRTs of a given duration by the number of opportunities. In a sample of responding, the number of opportunities for a response in a given time period is the number of IRTs in that period plus the number of longer IRTs.

24
Figure 3. Mean inter-response time per opportunity as a function of IRT in seconds for individual subjects.
Figure 3

<table>
<thead>
<tr>
<th>S-1</th>
<th>S-2</th>
<th>S-3</th>
<th>S-4</th>
<th>S-5</th>
<th>S-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲ LOW RATE</td>
<td>○ HIGH RATE</td>
<td>▲ LOW RATE</td>
<td>○ HIGH RATE</td>
<td>▲ LOW RATE</td>
<td>○ HIGH RATE</td>
</tr>
</tbody>
</table>

Mean IRT/OP vs. IRT (SECS)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Although the IRT data were collected for a period of 10.1 sec, the distributions were truncated at five sec, since 95% of the IRTs for each of the subjects are contained within the first 50 bins. The data corresponding to IRTs greater than five sec (comprising the dump bin in this calculation) are excluded. The divisor in the calculation of IRT/OP gets smaller with each successive calculation until the dump bin is reached. The number recorded in this counter is then divided by itself, and therefore always yields a value of one. Traditionally, this data point is not plotted (Nevin, 1973). In addition, the data were combined into 0.5 sec class intervals for the abcissa of Figure 3 in order to facilitate graphic analysis.

The data in Figure 3 were derived by averaging the IRT distributions for individual subjects across the three baseline sessions prior to the first presentation of response-independent food during dark-key periods. Under the TAND VI, T1 sec ≤ IRT ≤ T2 sec contingency, only responses which terminate IRTs within the specified bandwidth are reinforced. Therefore, the peaks of the IRT/OP distributions would be expected to occur between 0.5 sec and 1.5 sec for the high-rate condition, and between 2.5 sec and 3.5 sec for the low-rate condition.

Examination of the data in Figure 3 shows differences between the IRT/OP distributions for responding maintained by the two pacing requirements. In all cases, the averaged probability of responding with IRTs within the 0.5 sec — 1.5 sec band is greater in the presence of the green stimulus than in the presence of the red stimulus. Except in one case (S-6) the distributions for the low-rate component peak at IRTs within the 2.5 sec — 3.5 band.
The data contained in Figure 3 show interaction between the schedule components in several different forms. The graphs for S-2 and S-5 show clear secondary peaks for IRTs associated with the high-rate contingency, which fall within the IRT band for the low-rate contingency. Additionally, for S-1 and S-4, the initial peak for the low-rate condition is one that is typical of response patterns in which subjects pause between bursts of responses. In the case of these subjects, bursts of responses with pauses of durations which met the $2.5 \text{ sec} \leq \text{IRT} \leq 3.5 \text{ sec}$ requirement were modal.

The IRT/OP distribution for S-6 demonstrates another type of interaction between high- and low-rate contingencies. In this case, the distribution for responding associated with the low-rate contingency peaks at a value between the two reinforced bands, suggesting a greater degree of control by the high-rate contingency. Although this subject responded with less differentiation between IRTs for the two schedule components, the reinforcement rates for doing so were only slightly lower than for the remaining five subjects, who showed more clear differences between IRT/OP distributions for the two conditions.

**Effects of Response-Independent Food**

In all of the remaining figures, response rates and latencies-to-respond are plotted on three-cycle logarithmically spaced ordinates. A three-cycle ordinate was chosen since this encompassed the range of the data presented. Nevin (1977, 1979) has advanced several arguments in favor of the use of logarithmic spacing in presentation of behavioral data: First, when dependent variables (especially response rate in Nevin's view) are transformed in this way, the slope of the function...
may be used to indicate resistance to change. In the case of response rate, for example, the greater the negative slope across levels of the response-weakening operation, the more weakened is responding. If latency-to-respond is taken as an indication of a subject's readiness to respond in a given situation, then weakness of the tendency to respond is reflected in a positive slope.

A second advantage of the logarithmic plot is that the slope of the obtained function remains invariant under any multiplicative transformation such as a change of units, or expression of the data relative to baseline, such as will be the case with the remaining figures.

Two additional considerations which recommend the logarithmic transformation should also be noted. The logarithmic transformation spreads-out data for low response rates, permitting estimation of slope differences which might otherwise be obscured by floor effects.

Finally, Nevin cites the pervasiveness of linearity in log-transformed data in many areas of science (see Gaddums, 1945; Gonzalez and Byrd, 1977). For a detailed discussion of the logarithmic plot, the reader is referred to Schmid and Schmid (1979).

Figure 4 is a summary figure which shows mean response rates and mean latencies, averaged across all six subjects, as a function of the magnitude of response-independent food presentations during dark-key periods. The ordinate is spaced logarithmically, and is scaled from 0.1 sec to 60 sec for latency, since schedule components terminated at this value. The ordinate for mean response rates is scaled from 0.1 to 100 responses per minute (R/MIN). The abscissa of Figure 4 is scaled linearally from zero sec, the baseline condition, to 15 sec, the
Figure 4. Mean response rate and mean latency as a function of response-independent food magnitude in seconds. Data are averaged across six subjects.
Figure 4

![Graph showing mean responses/min and mean latency (secs) against response-independent food magnitude (secs).](image)

- △ RED (LOW RATE)
- ○ GREEN (HIGH RATE)
- ▲ RED (LOW LATENCY)
- ● GREEN (HIGH LATENCY)

N=6

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
maximum magnitude of response-independent food employed. Changes in
mean response rates are depicted by the open symbols and dashed lines,
while those for mean latencies are represented by filled symbols and solid
lines. The vertical bars surrounding the baseline data points represent
one standard deviation around the respective means, and reflect the
variability encountered in the baseline condition. Baseline data
were derived by averaging three-day baseline periods prior to each test
session across the entire testing phase of the experiment, and across
subjects. Note that while response rates were clearly differentiated
for the two schedule components during the baseline period, averaged
latencies showed considerable variability, and hence the bars which
represent standard deviation overlap.

The data contained in Figure 4 demonstrate functional relationships
between both dependent measures and the magnitude of response-independent
food presentations during the dark-key period. As the amount of response-
independent food delivered in test sessions increases, mean response
rates decrease and mean latencies increase. Comparisons of the slopes
for the mean response rate functions shows that, on the average, high-
and low-response rates were affected equally by the response-weakening
operation. Similarly, except for more variability across the levels of
the independent variable, mean latencies also varied linearally with
increases in the magnitude of response-independent food presentations.

Figure 5 represents the functions for individual subjects from
which the data in Figure 4 are derived. The ordinates and abcissas of
this figure are scaled as in Figure four. Mean response rates and mean
latencies for individual subjects are presented as a function of
Figure 5. Mean response rate and mean latency as a function of response-independent food magnitude in seconds for individual subjects.
Figure 5

MEAN RESPONSES/MIN

MEAN LATENCY (SECS)

RESPONSE-INDEPENDENT FOOD MAGNITUDE (SECS)

LOW RATE  HIGH RATE
LOW LATENCY  HIGH LATENCY

S-1  S-2  S-3  S-4  S-5  S-6
response-independent food magnitude during dark-key periods. Baseline means and standard deviations were derived by averaging three-day baseline periods prior to each test session, for each subject, across the testing phase of the experiment. The remaining data points for each subject represent the means of three test sessions conducted at each level of the independent variable. As in Figure 4, open symbols and dashed-lines represent mean response rates, while filled symbols and solid lines depict mean latencies-to-respond.

Generally, the mean response rate functions presented in Figure 5 show that the group means presented in Figure 4 are representative of the performances of individual subjects in this experiment. However, considerable variability is evident for the latency measure. Although the trends for the latency measure are essentially linear, inspection of these data reveals more individual idiosyncracy than is evident from inspection of the response rate functions. Note for example, that the latency function associated with the low-response rate contingency for S-2 is characterized by a large initial change, followed by little or no increase, while the latency function associated with the high-response rate contingency increases at a steady rate across the levels of the independent variable. Comparison of the response rate and latency functions for this subject reveal inconsistency between the two measures insofar as the response rate function associated with the low-rate contingency shows a large initial decrement followed by a steady rate of change across the levels of response-independent food magnitude. Otherwise, the data for the remaining five subjects generally shows consistency between the response rate and latency
measures.

The data presented in Figures 6, 7 and 8 show the effects of response-independent food on latency-to-respond for individual subjects, within randomly selected sessions, for the baseline period and three levels of the independent variable. Latencies are shown for each subject as a function of trials within single sessions. The dashed lines across the tops of the graphs represent the durations of schedule components. Schedule components were 60 sec long, and thus a ceiling was imposed on the latency measure. There were 20 high-rate and 20 low-rate components within each session. For purposes of presentation, a trial is arbitrarily defined as the successive presentation of one red and one green stimulus. There were, therefore, a total of 40 schedule components within each session. Since a multiple schedule was used, the components were presented serially.

The data in Figures 6, 7 and 8 show the patterns of latencies-to-respond in the presence of the stimuli correlated with the high- and low-rate contingencies. Beginning with the leftmost panels (baselines), Subjects one and two (Figure 6) show clear differentiation between the two functions. For these two subjects, latency to respond was clearly affected by the contingencies on response rate, since the ordering of the functions is consistent with the ordering of the rate contingencies. Longer latencies are related to lower response rates, while shorter latencies are related to high response rates. The baseline data for the remaining four subjects shows no such effect (compare the leftmost panels of Figure 6 with those of Figures 7 and 8).

The remaining data in Figure 6, 7 and 8 illustrate the effects of
Figure 6. Latency as a function of trials within individual sessions of response-independent food presentation (Subjects 1 and 2).
Figure 7. Latency as a function of trials within individual sessions of response-independent food presentation (Subjects 3 and 4).
Figure 8. Latency as a function of trials within individual sessions of response-independent food presentation (Subjects 5 and 6).
three levels of the independent variable. As the magnitude of response-independent food presentation increases, there is a general increase in latencies both within and across sessions, except at the extreme low value of response-independent food magnitude where latency was little affected. Only one panel shows departure from the trend described above. Subject 6 showed a consistent decline in latency across the session in which response-independent food magnitude was 7.5 seconds.

One other feature of the data presented in Figure 6, 7 and 8 bears comment here. Note, especially for S-5, several extremely short latencies. These data points result from increased responding following response-independent food presentations during the intervening dark-key periods. Five of the six subjects showed some increase in dark-key responding during test sessions. The remaining subject showed little tendency to respond to the dark-key regardless of the circumstances.
DISCUSSION

The results of the present experiment support the conclusion that, given equal reinforcement rates, pacing contingencies do not affect relative resistance to change. The present data provide no evidence that differences in either the temporal patterns of response, or the number of responses emitted under VI schedules, result in differences in response strength. Despite the fact that different performances are evident in the baseline condition, neither response rate, nor latency-to-respond is differentially affected by the introduction of response-independent food. Both of these dependent measures varied systematically with changes in the magnitude of response-independent food presentations during dark-key periods. As magnitude of response-independent food increased, response rates decreased, and latencies to respond increased. To the extent which the two dependent measures vary systematically with increases in the value of the response weakening operation, changes in either may be taken as indices of response strength.

These data, taken together with those of Fath and Malott (1979) support Nevin's (1974, 1979) conclusion that reinforcement frequency is a strong determinant of resistance to change, regardless of the observed baseline response rates. That latency to respond also varies systematically with changes in the response-weakening operation, lends added support to Nevin's conceptualization of response strength as resistance to change. To the extent which various measures of the tendency to respond change in a consistent manner with the parameters of reinforcement (e.g. delay, frequency, or magnitude), the associated
concept of response strength is supported as potentially useful.

The results of the present study confirm Nevin's approach to the quantification of response strength by demonstrating that relative resistance to change is equal, given equal reinforcement rates. The failure to support Nevin's (1974, Exp V) suggestion that high- and low-rate requirements produce differences in resistance to change in no way invalidates Nevin's approach; rather the present findings simply indicate that contingencies on response rate which have the same formal properties have no effect on response strength.

The present data provide no evidence that differences in temporal patterns of responding result in differences in resistance to change, given that reinforcement frequencies for those patterns are equal. Contrary to the findings of Blackman (1968), neither high- nor low-rate contingencies differentially affect response strength. Blackman demonstrated that both response rate and reinforcement frequency may affect conditioned suppression. In Experiment II of his study, high response rates were subject to more suppression than low response rates when reinforcement rates were equated in two components of a multiple schedule.

Blackman suggested that high response rates may be less resistant to change because subjects responding at high rates necessarily make more responses per reinforcement than those responding at low rates. Thus, behavior with which the ratio of responses to reinforcements is high may be more susceptible to suppressive operations. The present data do not support Blackman's conjecture. The high-rate contingency employed here maintained response rates approximately twice as fast as
those maintained by the low-rate contingency, yet behaviors maintained by both contingencies were equally resistant to change.

The reasons for the discrepancy between Blackman's (1968) findings and the results of the present study are unclear. Blackman ruled-out adventitious punishment of responding by pairing his conditional stimulus (tone) and unconditional stimulus (shock) prior to bar-press training his rats. Differences in the availability of reinforcement for high- and low-rates of responses may also be ruled-out, since Blackman's data clearly show that the obtained reinforcement rates for both classes of responding were approximately equal, and close to the nominal schedule values.

Species differences between Blackman's study and ours may account for the differences in results. Rats typically respond at lower rates than pigeons. It may be that the high response rates required of Blackman's subjects were close to the upper limit which this species is able to maintain for long periods of time. In this case, fatigue may have combined with the effects of the conditioned suppression operation to reduce the high-rate response more than the latter operation would by itself. However, no clear statement can be made on this issue at this time. It would be best to arrange an experiment where both species can be compared directly under similar conditions in order to resolve this question.

The finding that behaviors maintained by different reinforcement frequencies are differentially resistant to change is supported by a number of studies using aversive consequences as the response-weakening operation. This fact suggests that Nevin's (1979)
conceptualization of response strength as resistance to change is valid across a variety of response weakening operations, and that the discrepancy between Blackman's (1968) results and those of the present study cannot be attributed to differences in the types of response weakening operations employed.

Church and Raymond (1967), using rats as subjects, found that electric shock reduced response rates more when the food reinforcement schedule was VI 2 min than when the schedule was VI 0.2 min. Similarly, De Villiers (1977), using a two-key concurrent procedure with pigeons as subjects, observed that shock produced greater suppression of behavior maintained by a VI 3 min schedule of food reinforcement than by a VI 1 min schedule. Bouzas (1978) obtained similar results with pigeons responding under a multiple schedule of food reinforcement. In contrast, however, when electric shock follows every response, suppression appears to be independent of the frequency of food reinforcement (Holz, 1968).

In a study by Bradshaw, Szabadi, and Bevan (1978), human subjects pressed a button for monetary reinforcement under a range of VI schedules specifying different reinforcement frequencies. In alternate sessions, responding was punished by subtraction of money. In the absence of punishment, response rate was an increasing, negatively accelerated function of reinforcement frequency. When punishment was introduced, responding maintained by lower frequencies of reinforcement was much more suppressed than that maintained under higher frequencies of reinforcement.

To the extent which results are consistent across species and
across a variety of response weakening operations, support is garnered for Nevin's conceptualization of response strength as resistance to change. Mandell (1980) compared the effects of extinction, satiation and free-food schedules on behavior maintained by reinforcement schedules which generate different temporal distributions of responses while holding overall reinforcement frequencies constant. In Experiments I and II of her study, Mandell arranged multiple FI/VI schedules of reinforcement with equal reinforcement rates. Decreases in response rates, relative to baseline, were approximately equal regardless of the temporal patterns of responding maintained by the two schedules.

Mandell (1980) was concerned that differences in resistance to change between VI and FI schedules may have been masked by the differences in the temporal patterns of behavior. Such concern is unwarranted in light of the present findings. Our data show that differences in temporal patterns of responding and number of responses per reinforcement are unrelated to relative resistance to change when reinforcement frequency is held constant.

Nevin (1974) introduced response strength as a term capable of summarizing a large number of diverse findings. A discriminated operant is defined by the three-term relation between a discriminative stimulus, a response, and a reinforcer. A "strong" operant may be identified in relation to other operants by the higher rate of occurrence of its response, relative to baseline, when some operation is applied to change response rates. The implication of this statement is, of course, that one cannot simply observe some
characteristic of a response such as its rate or latency in isolation, and proceed to infer strength on that basis. Rather, inferences concerning strength must: 1) be identified in relation to at least one other operant, and 2) some operation must take place which disrupts at least one of the operants in question. In this way, it is possible to make at least ordinal comparisons. Further, several levels of the response weakening operation should be employed, since no single measure is, by itself, informative. It may be, as Nevin (1979) notes, that responding maintained by a particular VI schedule is unaffected by a particular amount of response-independent food, because that amount would leave any performance unchanged.

The question of a suitable quantitative measure of response strength remains unresolved at present. At different times (Nevin, 1977 and Nevin and Mandell, 1977), the ratio of the slopes of functions fitted to log transformed data, or differences in the logarithms of the relative decrements at a particular value of the disruptor variable have been discussed, and dismissed as premature (Nevin, 1979). To date comparison of ordinal differences, and concern with the generality of effects have been emphasized.

It is useful at this point to consider some of the problems which are encountered in the search for an appropriate metric for resistance to change. Throughout the following discussion, the procedure for accessing response strength should be kept in mind: A multiple schedule of reinforcement is in effect. Upon achieving baseline stability, a disruptor variable is introduced, and changes in response rate, relative to baseline, are observed. If responding weakens, a
negative slope is apparent in the function relating log-response rate to increasing values of the disruptor variable.

The first problem comes with the identification of "weakness" with negatively-sloped functions. So long as the index of resistance to change consists of changes in response rates relative to their respective baselines, negative slopes may be taken as an indication of weakness. If some other dependent measure, such as latency to respond, which increases as the tendency to respond weakens, is employed, then a negative slope indicates strengthening of the operant in question, rather than weakening.

The problem described above is more apparent than real. So long as the properties of the dependent variable under observation are kept in mind, no conceptual difficulty is encountered. For those who do have difficulty, however, another possible solution exists. In the case of latency, for example, one could transform this dependent variable to a latency rate measure \( \frac{1}{\text{latency} \text{ (secs)}} = \frac{R}{\text{sec}} \).

However, this reciprocal transformation is inadvisable since it obscures the absolute values of the latencies involved. It is also unclear as to whether plotting the results of a reciprocal transformation on logarithmic coordinates is justifiable. The result, in any case, is two transformations of the original data, and thus two steps removed from the original observation.

A case where the identification of weakness with decreases in response rate may be inappropriate arises when response rate is considered in relation to the contingencies by which it is supported. Consider, for example, the VI 1 min, 2.5 sec \( \leq IRT \leq 3.5 \text{ sec} \) contingency.
employed in the present experiment. An optimal response rate under this contingency, one which maximizes the likelihood of collecting all scheduled reinforcers as they become available, is approximately 20 responses per minute (about one response every three sec). In practice, the observed response rates are somewhat faster (between approximately 25-40/min). Thus, any operation which reduces responding in such a way that the rate approaches the optimal response rate, will actually strengthen behavior by increasing the likelihood of success with respect to the prevailing contingencies of reinforcement. In contrast, any operation which increases response rate under these circumstances actually weakens behavior, since the likelihood of reinforcement will decrease as response rate increases under the low-rate contingency.

In a similar vein, consider the application of the low-rate contingency to the preceding VI 1 min baseline. Response rates will certainly decrease relative to the previous baseline as requirements for lower and lower response rates are introduced. However, one would hesitate to infer changes in strength, since lower response rates are required in order to satisfy the reinforcement contingency. Rather, more precise definition of the response-weakening operation is indicated.

Currently, response-weakening operations are defined solely in terms of their ability to disrupt ongoing behavior. A more precise definition must take into account the effectiveness of responding with respect to the contingencies which maintain a particular behavior pattern. If the likelihood of an organism's success with respect to the contingencies which maintain its behavior is consistently impaired by some operation, then the operation may be said to weaken
responding. Emphasis is placed on the notion of consistency in order to eliminate such effects as may be observed with the introduction of response rate-contingencies. The disruptive effect of introducing contingencies on response rate is transient. A subject's success with respect to rate contingencies is temporarily disrupted, but as the organism is reinforced for responding appropriately, success, mirrored by higher reinforcement rates, becomes evident.

Similarly, transient changes in the stimulus environment, such as when the experimenter forgets to turn on a white noise generator before the daily session, may also disrupt responding temporarily. However, since behavior recovers quickly under these conditions, it would be unwise to classify this type of event as a true response-weakening operation.

It may, of course, be argued that even events which disrupt behavior only temporarily should be classified as response-weakening operations, since lack of success with respect to the reinforcement contingencies is, nonetheless, lack of success. In this case, a division of the class of response-weakening operations is needed. Some operations would fall into a category of events which produces transient changes in the effectiveness of behavior, while others would fall into a second class whose effects are more permanently disruptive.

In conclusion, it should be noted that none of the above criticisms seriously challenges Nevin's (1974, 1979) approach to the quantification of response strength. The mass of orderly data which is currently being generated by experiments designed to assess resistance to change suggests, rather, that Nevin's approach is to be recommended as a
means toward the end of understanding the variables which control behavior.
Bibliography


54

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.


