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ESCAPE FROM AN EFFORTFUL SITUATION[1]

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This experiment investigated the tendency to escape from a situation requiring effortful responding. Five human subjects responded in a situation where the response mechanism required 20-lb force to operate; responses were reinforced according to a variable-interval schedule. A subject escaped from this situation by emitting a vocal response which produced a 60-sec "easy period". During the easy period the reinforcement contingency was switched to a response mechanism requiring 1 lb to operate. It was found that: (1) Escape responding could be conditioned and maintained by producing the easy period; the easy period did not maintain escape responding when the force requirement in the normal situation was equated with it. (2) The rate of escape responding was a function of the magnitude of the force normally required. (3) When easy periods were scheduled after fixed ratios, pausing from the end of the previous easy period to the first escape response was noted. It was concluded that a situation requiring high-force responding is a negative reinforcer. The pattern of fixed-ratio responding suggests that this reinforcer produces typical schedule control in human subjects.

One condition of every operant experiment is the amount of force required to operate the response mechanism. Chung (1965) found that when this requirement is high the rate of variable-interval responding is reduced. Many other experimental conditions that reduce the rate of responding have been found to maintain responses that terminate or alter those conditions. Examples of such conditions include shock punishment (Azrin, Hake, Holz, and Hutchinson, 1965), unavoidable shock (Azrin, Holz, Hake, and Ayllon, 1963), and infrequent reinforcement (Findley, 1958). Thus, the reduction in rate of responding produced by a high-force requirement suggests that it may also maintain behavior which terminates or alters those experimental conditions.

Chung (1965) conducted a second experiment related to this possibility. He permitted subjects to respond on either a high- or a low-force key. One could predict that if the high-force key produced a tendency to escape then subjects would show a greater tendency to respond on the easy key. However, he found that they spent approximately the same amount of time on both keys. This finding would seem to indicate that a high-force requirement does not produce a tendency to escape.

However, there is an alternative interpretation of the results. Chung concurrently programmed reinforcements according to a variable-interval schedule on both keys simultaneously. Findley (1958) found that this type of concurrent schedule maintained a considerable amount of switching between two keys. He explained this by pointing out that the subject maximized reinforcements by responding on both keys frequently and that switching was occasionally followed by a reinforcement. These points suggest, then, that the particular type of concurrent schedule used by Chung may have obscured any escape tendencies produced by the high-force requirement.

The present experiment explored the possibility that a high-force requirement does result in a tendency to escape. The interaction between reinforcement density and force requirement was eliminated by scheduling reinforcements for only one response at a time.

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This is done by requiring an explicit escape response that switches the reinforcement contingency to the easy manipulandum for 60 sec; during that period of time reinforcements are not scheduled on the hard manipulandum. After the 60-sec easy period, the contingency is switched back to the hard manipulandum until the next escape response occurs. This design permits an assessment of the tendency for subjects to escape or switch from a situation involving a high-force requirement.

METHOD

Five human subjects differed with respect to age, sex, psychiatric classification, and reinforcer used. Table 1 lists these characteristics for each subject. The only criterion used in selecting subjects was that they accept money or cigarettes and come to the laboratory regularly.

Table 1
Subject Description

	Classification	*Age*	*Sex*	*Reinforcer*
S-1	Normal	17	Male	Nickels
S-2	Normal	17	Female	Nickels
S-3	Schizophrenic	30	Female	Pennies
S-4	Schizophrenic	43	Male	Cigarettes
S-5	Schizophrenic	40	Male	Pennies

Apparatus

The experimental room was a 6 by 6 by 8 ft sound-attenuated room. One arm of the subject's chair was hinged to a workbench that extended the length of one wall. When the chair was pulled into position in front of the workbench, the subject could insert a jack connected to the table into a plug mounted on the chair. Two Lindsley knobs (Lindsley, 1956) and five stimulus lights were mounted in a Micarta box attached to the bench directly in front of the chair. The force required to pull the knob through a 1.0-in. distance was controlled by compression springs attached to the shaft of the knobs. Reinforcers were delivered within reach of the subject by a Universal feeder located at the right end of the bench. Vocal responses were detected by a concealed microphone fixed to the wall directly behind and above the Micarta box. The microphone was connected to a Gerbrands voice-operated relay. All other conditions were arranged by timers and relay circuitry located in an adjoining control room. Cumulative recorders and counters recorded knob-pulls and vocalization. All wiring within the experimental room was concealed by a false bottom on the workbench. The experimenter also had direct visual access to the subject through an observation window concealed in a false air vent. Figure 1 depicts the room.

Procedure

Each subject was trained to enter and leave the experimental room unaided. He was given the following instructions before the first experimental session:

> "Sit in the waiting room until the sign saying ready in room #2 flashes on. Then walk down the hall, enter the room, close the door, and sit in this chair. Pull the chair around so that you are facing this box. When the door is closed and the chair is in place, the white light will go on indicating that the equipment is running. As long as the white light is on, you can get some cigarettes (money) from this machine. The only cigarettes (money) you get will come from the machine. When your light goes off, you may leave the room."

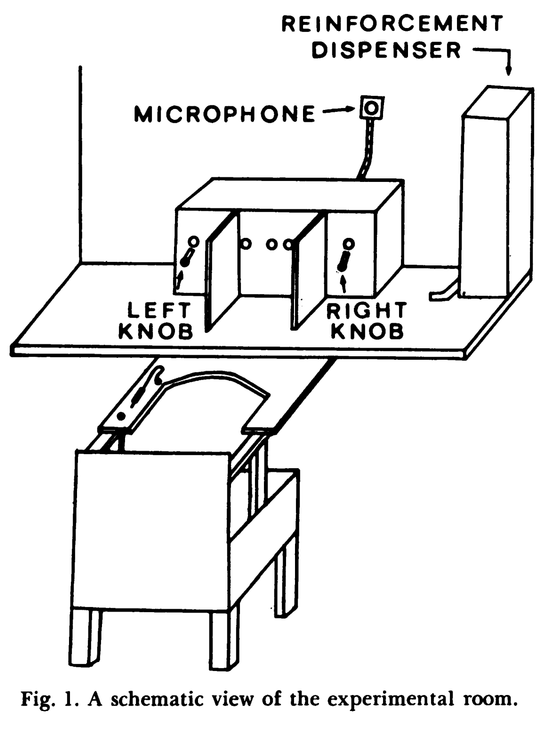

Fig. 1. A schematic view of the experimental room.

After the subject had correctly followed these instructions, he was returned to the waiting room to wait for the first session to begin. If a subject failed to follow these instructions on subsequent days, part or all of the instructions were repeated. No instructions concerning other aspects of the situation were given. Virtually no social contact occurred between the experimenter and the subject after the first session.

During the first session, each subject was exposed to a continuous schedule of reinforcement (CRF) that alternated from the left knob to the right knob. When the light above the left knob was on, each pull on the left knob was reinforced; when the light above the right knob was on, each pull on the right knob was reinforced. The light was alternated from one knob to the other after every five reinforcements. During the next session, the light was changed every 5 min and reinforcements were scheduled after variable intervals averaging 15 sec (VI 0.25-min). A scheduled reinforcement was cancelled if the subject had not pulled the correct knob within 5 sec (limited hold 5 sec). On following days, the schedule of reinforcement was gradually increased to a variable interval of 1 min (VI 1-min) with the limited hold remaining at 5 sec. Separate VI timers were used for each knob; this ensured that reinforcements for each knob were scheduled independently. Each VI-timer ran only when the corresponding knob light was on. During this time, each knob required 1 lb of force to operate. Each subject was continued for a number of sessions on the 1-lb force requirement until a stable rate of pulling emerged for each knob. The force requirement on the right knob was then increased to 20 lb with no other changes being made. This initial training period was considered complete when a stable rate of pulling had emerged on both the 20-lb right knob and the 1-lb left knob.

A vocal escape procedure was instituted after the pretraining period had been completed. This procedure differed from the pretraining procedure in two ways. First, only pulls on the 20-lb right knob were normally reinforced; the reinforcement contingency no longer shifted to the 1-lb left knob after 5 min. Second, a vocal response switched the reinforcement contingency from the 20-lb knob to the 1-lb knob for a 60-sec "easy period". The vocal response had to be preceded by at least one pull on the 20-lb knob; this forced the subject repeatedly to exert the 20-lb force before he could escape from it. This procedure permitted the subject to escape from a 20-lb to a 1-lb force requirement by vocalizing. This procedure is diagrammed in Fig. 2. Since no instructions were used, the vocal responding of each subject was shaped during the first sessions of this procedure. The experimenter immediately switched the reinforcement contingency from the 20-lb knob to the 1-lb knob when he heard a vocal sound. When the subject began responding loud enough to activate the voice-operated relay, the switching of the reinforcement contingency was controlled solely by the apparatus. Every subject was successfully conditioned to emit vocal responses by this procedure.

In subsequent sessions, the loudness requirement was progressively increased for every subject. The final level varied from 90 db for S-2 to 102 db for S-1. Each subject was exposed to the final loudness requirement until a stereotyped vocal response had emerged. One subject began by saying "I am super-secret agent Jack. I've gotta make a report to Washington." He ended up 20 days later saying "Wa". Other subjects coughed or said words such as "hello", "four", and "please". This training took an average of 10

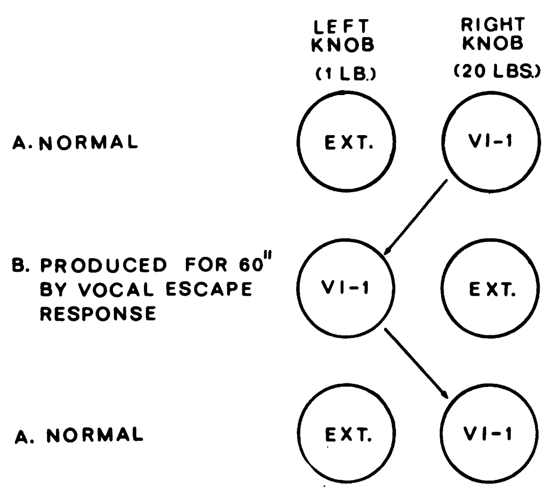

Fig. 2. Diagram of the escape contingency. Normally, pulls on the 20-lb knob are reinforced and pulls on the 1-lb knob are extinguished. A vocal response produces a 60-sec escape period during which reinforcements are produced by pulls on the 1-lb knob and extinguished for pulls on the 20-lb knob.

sessions. A stereotyped reponse emerged in every subject.

The successful conditioning of the vocal response suggests that terminating a high-force situation and producing an easy period is reinforcing. This question was experimentally evaluated by comparing the vocal rate maintained by terminating a 20-lb force requirement with the vocal rate maintained by terminating a 1-lb force requirement. The comparison was made in three phases. During the first phase, the force requirement was 20 lb on the right knob and 1 lb on the left knob. Thus, a vocal response produced a decrease in the force requirement during the 60-sec easy period. During the second phase, the force requirement was set at 1 lb for both knobs. Thus, a vocal response produced no force reduction during the easy period; instead, it merely permitted the subject to shift from pulling the right knob with 1-lb force to pulling the left knob with 1-lb force. During the third phase, the force requirement was again set at 20 lb on the right knob. Thus, a vocal response again produced a force reduction from 20 lb to 1 lb. The second and third phases were introduced only after the rate of knob-pulling and vocal responding had stabilized for at least three days during the previous phase. These rates were considered stable either when there was no apparent trend from one day to the next or when the change in rate was no more than 10%. The minimum exposure to any one condition was seven sessions.

As a further step in determining the relationship between vocal responding and force reduction, three of the subjects were studied at a series of force requirements ranging from 1 lb to 40 lb. After a subject's performance stabilized at one force requirement, he was raised to the next higher one. The same stability criteria were used for this part of the experiment. The minimum exposure to any one value was four days with an average of 14 days for each value.

Finally, to explore the effect of intermittent scheduling, termination of the effortful situation was programmed according to fixed-ratio schedules varying for one subject from FR 1 to FR 20 and for the other subject from FR 1 to FR 50. The effect of two different force requirements on fixed-ratio responding was also explored with this second subject.

RESULTS

Figure 3 shows the rate of vocal escape responding for each subject for every day of the

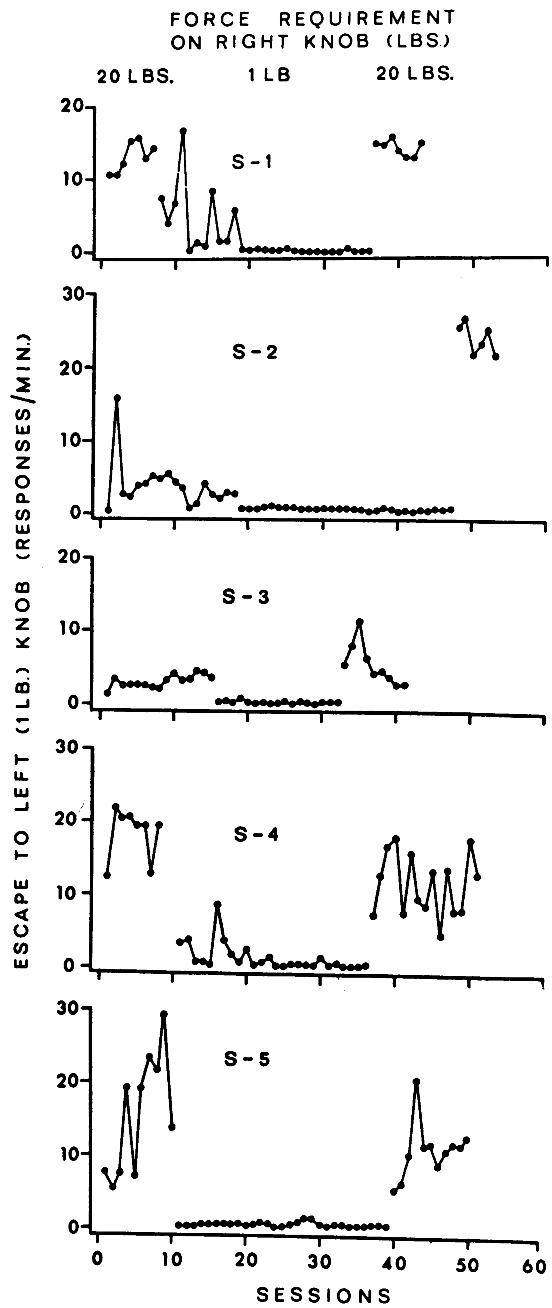

Fig. 3. Average rate of escape during daily sessions during three phases. During first and third phase an escape response switched the reinforcement contingency from a 20-lb to a 1-lb force requirement. During the second phase, both knobs were set at a 1-lb force requirement so that an escape response did not change the force requirement.

Table 2
Rate of Response (in Min) and Rate of Reinforcement (in Min) on Both Knobs

Subject	*Response/min* Left (1 lb)	Right (20 lb)	*Reinforcement/min* Left (1 lb)	Right (20 lb)
S-1	228	15	0.95	0.56
S-2	172	65	0.93	1.37
S-3	131	124	0.94	0.92
S-4	168	54	0.93	1.01
S-5	239	61	0.94	1.13
S-1*	152	105	0.97	0.92

*Data with corrected limited-hold procedure; right knob at 10 lb.

experiment. In calculating rate, the 60-sec periods of escape are treated as reinforcements and that time is subtracted from the total session time; this leaves the amount of time that the vocal escape response could be emitted as the basis for calculating the rate. The results for S-1 may be used to illustrate the general results for all of the subjects. During the first phase, when a vocal response produced a force reduction, S-1 vocalized at about 15 responses per min. During the second phase, when a vocal response did not produce a force reduction, the rate of vocalizing for S-1 fell to a near zero rate after 11 sessions; his rate remained at that level for the next 17 sessions. During the third phase, when a vocal response again produced a force reduction, S-1 vocalized at about 15 responses per min. The results for the other subjects demonstrated the same effect of force reduction on vocalization; only the specific rates of responding and the rapidity of extinction differed. For all subjects, then, when force reduction resulted, vocal responding was maintained; when force reduction did not result, vocal responding extinguished. These data show that vocal responding can be maintained by terminating an effortful situation.

The question arises, however, as to whether the difference in force was the only variable maintaining vocal responding. It is possible that the subject responded more slowly on the right knob because of the 20-lb force requirement. If this was true, then the response rate may have been so low that the subjects missed some of the scheduled reinforcements. The result would be that vocalization not only reduced the force but that it also produced an increased rate of reinforcement. Under these circumstances it would be impossible to assess the separate effects of the force and reinforcement variables.

The columns labeled "Responses/min" in Table 2 show that the rate of responding on the 20-lb knob was lower than the rate on the 1-lb knob for every subject. The right-hand column in Table 2 shows the rate of reinforcement on the 20-lb knob and the 1-lb knob for each subject. The rates are similar for both knobs for three of the subjects (S-3, S-4, S-5); reinforcements were produced at higher rate on the 20-lb knob by one subject (S-2) and at a considerably lower rate on the 20-lb knob by another subject (S-1). Thus, the data indicate that four out of five of the subjects did not produce reinforcements at a higher rate as a result of escape.

The results for the one deviant case, S-1, are partly an artifact of the limited-hold procedure that was in effect with him. It was possible for a vocal response to be made after a reinforcement had been scheduled for the right knob. Since the subject switched from the right knob to the left knob after a vocal response, this reinforcement would be cancelled by the limited-hold procedure after 5 sec. Therefore, since the subject switched from pulling the right knob to pulling the left knob after a vocal response, the subject would miss this reinforcement. This procedural error was corrected for all of the subjects by scheduling the reinforcement again after the 60-sec escape period ended. The results for S-1 with the corrected procedure appear in the bottom row of Table 2. With the corrected procedure S-1 produced reinforcements at approximately the same rate for both knobs. These results indicate that force reduction also maintained the vocal response for S-1. Taken together with the results for the other subjects, it may be concluded that vocal responding can be maintained exclusively by reducing the force required to respond.

Figure 4 illustrates the vocal escape responding for two subjects. The records are for the last three days of the first phase when

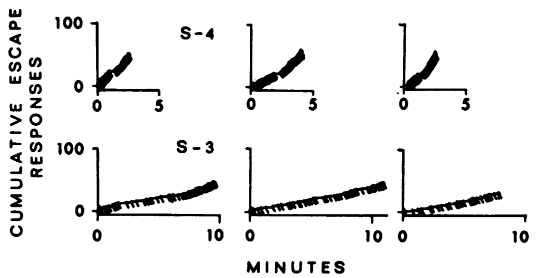

Fig. 4. Cumulative records of last three sessions during which these subjects escaped from a 20-lb to a 1-lb force requirement. S-4 had the highest escape rate and S-3 had the lowest. The cumulative recorder was stopped and the pen deflected downward during the 60-sec escape periods.

a vocal response produced a force reduction from 20 lb to 1 lb. A fairly uniform rate of vocal responding is maintained by both subjects. The other subjects developed vocal rates varying between these two extremes but with a similar pattern.

Figure 5 shows the vocal rate as a function of different force requirements on the right knob ranging from 1 lb to 40 lb. The function shows that vocal rate is an increasing function of the force requirement. Only a very slight effect is noticed when the vocal response produced escape from 5 lb. The first significant effect seems to occur at about 10 lb. After further increases, each subject appears to reach an asymptote. This asymptote is reached at 20 lb for S-3 and S-4 and at 30 lb for S-2. These data show that as the right knob became harder to pull, subjects escaped from it more rapidly.

If escape from an effortful situation is similar to other reinforcing events, then it should be possible to maintain escape responding by use of an intermittent schedule. To investigate this possibility the escape requirement was changed to a fixed-ratio schedule for two subjects. This meant that the subjects had to emit a number of vocal responses (depending on the size of the ratio) to escape. Ratio size was gradually increased to 20 responses for S-4 and to 50 responses for S-1.

Figure 6 shows the pattern of responding for S-1 at several ratio sizes which escaped from a 10-lb force requirement. In this figure, the 60-sec period of escape is indicated by a downward pip of the pen and is designated the "easy period"; the recording pen is stopped for the duration of each easy period. When only one vocal response was required to produce an easy period (FR 1), the response usually occurred within a few seconds of the end of the previous easy period. As the number of responses required to produce an easy period

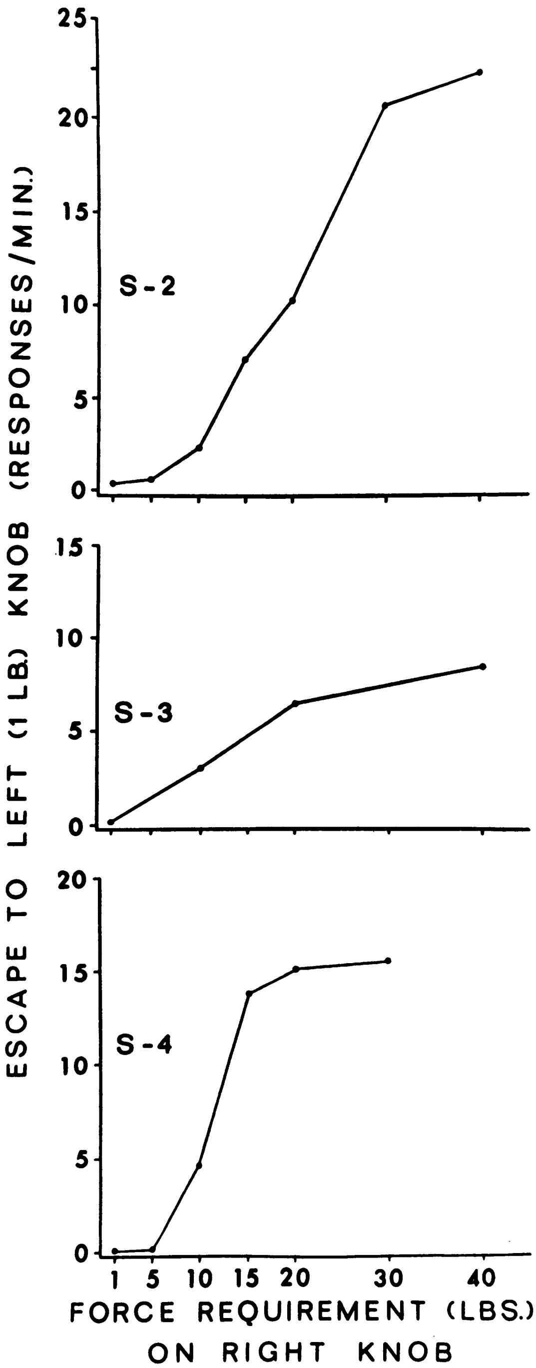

Fig. 5. Rate of escape from different force requirements. Each point represents the average of three consecutive sessions.

increased, the pause from the end of an easy period to the first response increased. Thus, when 50 responses were required (FR 50), the average pause was over 1 min.

Figure 7 shows that the average pause length increases as the size of the ratio increases. Similar results were obtained with S-4. It is interesting to note that when the force requirement that the subject was escaping from was 20 lb instead of 10 lb, the pause length shortened to less than 5 sec, and showed no increase with the size of the ratio (up to FR 100). Thus, a high-force requirement apparently produces an increased tendency to escape from it. The results indicate that escape from a situation involving a high-force requirement will maintain fixed-ratio responding. Further, they suggest that the typical fixed-ratio pattern of pausing after reinforcement occurs at intermediate force requirement values.

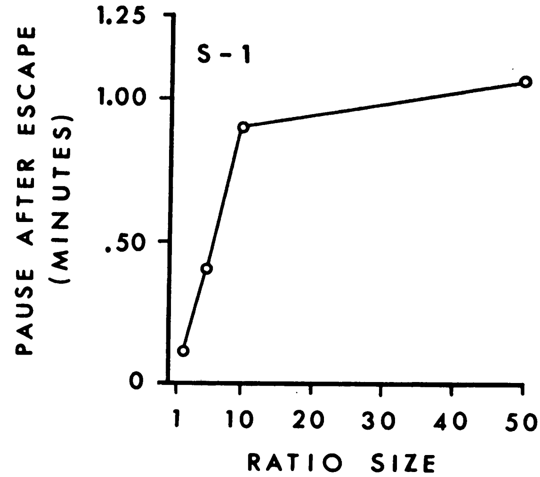

Fig. 7. Average length of pause from the end of an escape period to the first escape response when escape periods are scheduled according to different sized fixed-ratio requirements.

DISCUSSION

These results may be cast in three interpretative frameworks. The first emphasizes the high-force situation and points to the termination of that situation as the most important feature of the experiment. The second em-

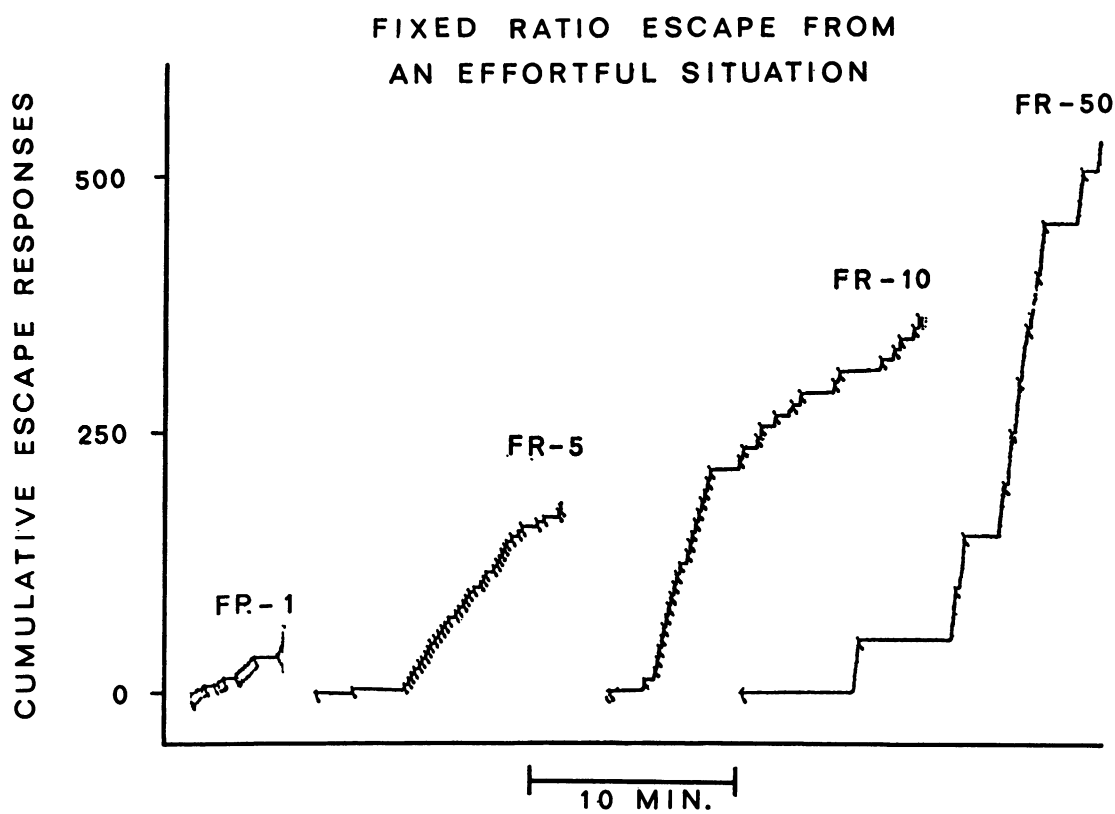

Fig. 6. Cumulative records of escape responding when escape periods were scheduled according to fixed-ratio requirements. Each escape period switched the reinforcement contingency from a 10-lb to a 1-lb force requirement. Cumulative recorder was stopped and the pen deflected during the 60-sec escape period.

phasizes the easy situation and points to production of that situation as the most important aspect. The third framework points to the "switch" from one situation to the other as the most important feature. The first framework leads to the conclusion that the high-force situation is a negative reinforcer; the second framework leads to the conclusion that the easy situation is a positive reinforcer; and the third framework uses a neutral description of the subject's "preference" for the low-force situation and leads to the conclusion that the switch is a reinforcing event.

On the surface it would appear that the switching interpretation is the soundest. It adopts a descriptive point of view that is neutral with respect to whether the production of the easy situation, or the termination of the hard situation is the critical feature of the procedure. In effect, it assumes that the two situations are not comparable and that the switch from one situation to the other is not correlated with a single stimulus dimension. Unfortunately, this is also the weakest interpretation. It simply promotes the conclusion that the force requirement in a situation makes a difference and adds it to the growing list of other variables capable of maintaining a switching response. At the same time it fails to relate this variable to other well-known behavioral effects.

It is possible to adopt a stronger interpretation of these results if negative reinforcement is defined as the maintenance of a response by the termination or reduction of a stimulus condition (Hake, in press; Herrnstein and Hineline, 1966; Millenson, 1967). In the present experiment, the switch from one force requirement to the other was accompanied by a reduction in the force requirement. The data on relative reinforcement densities in the two conditions (Table 2) indicate that force reduction is the critical variable in maintaining the vocal response. The adoption of this expanded definition leads to the conclusion that a situation involving a high-force requirement is a negative reinforcer and an aversive stimulus.

The present experiment also suggests one very seductive conclusion: that the high-force stimulus itself is an aversive stimulus. Such a conclusion would support Chung's (1965) suggestion that the effects of the high-force stimulus on response rate be analyzed as a form of punishment. Unfortunately, this conclusion does not follow from the present experiment. The results show that the situation is aversive, but not that the high-force stimulus itself is aversive. In order to investigate this latter question it would be necessary to present the force stimulus non-contingently to a subject—in the same sense that a subject can be non-contingently shocked. Escape from such a non-contingent presentation would provide direct evidence that the force stimulus is aversive. Unfortunately, however, it cannot be presented to a subject non-contingently; the subject comes into contact with the high-force stimulus contingent upon making a response. Thus, escape from the stimulus cannot be directly studied; and in turn the direct verification of the aversiveness of the high-force stimulus is not possible.

In spite of this difficulty, the analysis of force as a form of punishment is very appealing. It may be useful to review the evidence that indirectly suggests that it is an aversive stimulus. Four effects are similar to the effects of shock. First, both the present study and Chung (1965) found that rate of responding during variable-interval reinforcement is reduced proportional to the amount of force required (*cf.* Azrin, 1960). Second, Chung (1965) found that when the force requirement is decreased to a new level, a temporary rate of responding is produced that is considerably higher than the stable rate produced by that level of force (*cf.* Azrin, 1960). Third, many investigators (Applezweig, 1951; Capehart, Viney, and Hulicka, 1958; Fitts, 1940; Lawson and Brownstein, 1957; Montgomery, 1951; Mowrer and Jones, 1943; Solomon, 1948; Weiss, 1961) have found that a high-force stimulus reduces the rate of responding during extinction (*cf.* Estes, 1944). Fourth, the present study found that a high-force requirement produced a tendency for the subject to escape (*cf.* Azrin *et al.*, 1965). Recently published data (Elsmore and Brownstein, 1968) suggest that the parallel suggested by response suppression may be partly an artifact of the occurrence of more abortive responses at high-force requirements. It is also possible that this suppression may reflect longer response durations. Nevertheless, these four parallels taken together provide some basis for considering high force to be an aversive stimulus. This in turn suggests the possibility of relating its effects to those of other aversive stimuli and other punishers.

The present results also indicate that force reduction may be a useful reinforcer for human subjects. Force reduction offers a combination of advantages over other reinforcers frequently used with humans. These advantages include: (1) the force stimulus can be completely specified in terms of physical dimensions; (2) it is not necessary or relevant to specify the subject's state of deprivation with respect to it; (3) the present procedure can be used with a wide variation of subjects as illustrated in the present experiment; (4) the high-force stimulus does not create the same administrative problems as electric shock; (5) the procedure does not require the use of instructions; (6) a response under its control can apparently be extinguished fairly rapidly without using special extinction procedures. This last point is particularly important in view of the fact that many subjects do not extinguish when counter-advances (Weiner, 1964c; Shearn, Sprague, and Rosenzweig, 1961) or signals (Lane, 1964) are no longer presented. This difference may also be related to the fact that fixed-ratio pausing was noted in the present experiment while it has not been observed when counter-advances (Weiner, 1964*a*, 1964*b*, 1965, 1966) or signal presentations (Holland, 1958) have been used as reinforcers. The use of force reduction as a reinforcer holds a promise of improved experimental control over human subjects.

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