THE MAINTENANCE OF BEHAVIOR BY THE TERMINATION AND ONSET OF INTENSE NOISE¹

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The purposes of the present investigation were, first, the establishment of the strength and temporal distribution of responses maintained by the termination and onset of a noise; and, secondly, the isolation of some of the variables which control such behavior.

METHOD

Subjects and apparatus

Forty-two white rats were used in this experiment.

The apparatus consisted of a lightproof and sound-resistant box containing a rat lever (Gerbrands) and a source of sound ("tweeter" loudspeaker). An essential feature of this equipment was a wire-mesh cage placed in the center of the larger box. The purpose of the wire-mesh cage was to insure that the animal was restricted within a uniform sound field. Preliminary experiments showed that the intensity of the sound rose sharply in the vicinity of the inner walls of the box, a possible factor in keeping the animal away from a lever mounted close to or through a wall.

The sound consisted of a signal containing all frequencies between 500 and 20,000 cycles per second. Sound intensities were measured by an H. H. Scott sound level meter, the microphone of which was placed in the vicinity of the lever at about the same height above the floor as the rat's head. Measurements were taken at other locations within the wire-mesh enclosure, and little variation in intensity was found. Intensities between 108 and 116 decibels were used.

The sound signal was switched at the output of the amplifier to minimize switching transients. During the time the sound was off the loudspeaker was short-circuited to prevent it from picking up any impulses from relay operation during this period. Unless otherwise stated, the switching of the sound signal was as rapid as the operation of the appropriate relay contacts. Further technical details will be found elsewhere (Barry & Harrison, 1957; Harrison & Tracy, 1955).

Two operants, R_P (the depression of the lever) and R_R (the return of the lever to its normal position), were used in this experiment.

Two schedules were used. In the first, the escape schedule of Keller (1941), an occurrence of R_P in the presence of sound was followed by three events: (1) the termination of the sound; (2) the initiation of a time interval, T_S (silent period); and (3) the restoration of the sound at the end of the time interval. An occurrence of R_P during the silent period was without effect on the animal's environment. An occurrence of R_R was also without experimental contingency. Rate of escape responding was obtained by dividing the total number of escape responses (i.e., R_P in presence of sound) by the total time the sound was on during the session.

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In the second schedule, the termination-onset schedule of Hefferline (1950), every occurrence of R_P terminated the sound and every occurrence of R_R produced the sound. In addition, every occurrence of R_R set the conditions under which R_P could occur, and every occurrence of R_P set the conditions under which R_R could occur. In the analysis of this schedule the termination of the sound is assumed to be part of the reinforcing complex of R_P , and the onset of the sound is assumed to be part of the negatively reinforcing complex of R_R . In addition, the duration of the silent period following the termination of the sound is part of the reinforcing complex of R_P , and the duration of the time the sound is on (the noisy period) is part of the negatively reinforcing complex of R_R . This analysis indicates that reinforcing conditions are least favorable during the early development of behavior under this schedule.

In this analysis of the Hefferline schedule no reference has been made to the animal holding the lever down. There are two reasons for this. First, the use of the term implies a class of responses which was not instrumented and about which, therefore, nothing can be said in these experiments. Secondly, when the word is normally used, holding refers to the time between an R_P and the succeeding R_R (i.e., the time the sound is off). However, the time between R_R and the succeeding R_P has the same status and, to be consistent, should also be referred to as holding (i.e., holding the sound on). But this is against common usage. Therefore, these time intervals will be designated simply as the time the sound is off (T_O) and the time the sound is on (T_S). Rates of the two responses (over a session) may be obtained from these two times as follows:

$$\text{Rate of } R_P = \frac{\text{Total number of } R_P}{\text{Sum } T_S}$$

$$\text{Rate of } R_R = \frac{\text{Total number of } R_R}{\text{Sum } T_O}$$

Cumulative Records

In both schedules the recording pen was stepped by all occurrences of R_P . In the escape schedule the reinforcing complex was indicated by displacement of the reinforcement marker for the duration of the silent period (T_O). In reading the cumulative records, it must be remembered that the pen may step during the displacement of the reinforcement marker, since the animal may respond during the silent period.

In the Hefferline schedule an occurrence of R_P stepped the recording pen and also displaced the reinforcement marker. An occurrence of R_R released the reinforcement marker. In these records, then, the displacement of the reinforcement marker indicates absence of the sound and has the same status as it has in the escape schedule.

Several recorders were used in the course of these experiments. On one of these the response pen stepped from *right to left* at a count of approximately 30 responses per inch. This expanded scale was used to increase the slope of records obtained from the characteristically low rates obtained with these schedules. Data shown in

Fig. 11, 12, 14, and 16 were taken on this recorder. Each response moved the pen down the paper one step; zero of the ordinate scale is at the top left-hand end of each record.

No shaping or other initial conditioning in the procedures were used. The 42 animals conditioned in the present experiments were run for sufficient periods to produce stable behavior. Operant rates of R_p prior to conditioning varied between zero and 5 responses per 1-hour session. R_R followed R_p within 1 second.

RESULTS

Description of the Behavior

Development of Escape Behavior. The development of escape from sound was found to be generally slower than that from electric shock (Dinsmoor & Hughes, 1956) and light (Keller, 1941; Kaplan, 1952, 1956). Development of similar behavior in humans (when laid over other responding) appears to be much more rapid than that reported here (Azrin, 1958). In Fig. 1, 2, 3, and 4 are shown cumulative records illustrating development patterns in four animals. The behavior shown in Fig. 1 is an example of the most rapid development found. Figures 2 and 3 show intermediate rates and patterns of development. The behavior shown in Fig. 4 was the weakest accepted in the present experiments. Though run for many hours beyond the fifteenth hour shown in the figure, this animal failed to increase its rate materially.

Stable Escape Behavior. The daily patterns of stable behavior given by any animal resembled one another closely with respect to the distribution of responses, though

Figure 1. Rat X. 36. Escape schedule, silent period 20 seconds. Cumulative records selected from the first 6 hours on the schedule. Displacement of the pen upwards indicates the sound is off (the reinforcing complex) in this and all other records.

Figure 2. Rat C. 1. Escape schedule, silent period 20 seconds. Cumulative records selected from the first 13 hours on this schedule.

the absolute number of responses given per day may vary greatly. The daily patterns of stable behavior obtained from different animals differed greatly in both number and distribution of responses. These points are illustrated in the records shown in Fig. 5, 6, 7, and 8. In Fig. 5 is shown an example of an animal with a small day-to-day variation and a steady working rate throughout the session. In Fig. 6 is shown the opposite extreme of oscillation. Oscillation persisted in this animal for 48 hours. Most animals fell between these two extremes. In Fig. 7 and 8 are shown characteristic changes in rate within sessions which were found as the persistent be-

Figure 3. Rat X. 46. Escape schedule, silent period 20 seconds. Cumulative records selected from the first 17 hours on the schedule.

Figure 4. Rat C. 3. Escape schedule, silent period 20 seconds. Cumulative records selected from the first 15 hours on the schedule.

havior patterns in many animals. The late-working animal shown in Fig. 8 is of considerable interest in representing the opposite of the so-called sensory adaptation which is said to take place in escape conditioning. Apart from the late-working animals, warm-up did *not* appear to be a characteristic of escape behavior.

Figure 5. Rat C. 10. Escape schedule, silent period 20 seconds. Cumulative records from the 43rd to the 47th hour on the schedule.

Withdrawal of Reinforcement. Reinforcement was withdrawn by leaving the sound continuously on; all other aspects of the schedule (including the operation of the reinforcement marker) remained unchanged. An example of the behavior over 6 sessions following the withdrawal of reinforcement is shown in Fig. 9. Since

Figure 6. Rat X. 45. Escape schedule, silent period 20 seconds. Cumulative records from the 33rd to the 38th hour on the schedule.

responding was no longer controlled by the occurrence of the silent period, the animal gave a series of high rate bursts indicated by *a*, *b*, and *c*. Response rate rapidly declined to a low value by the end of the session.

Figure 7. Rat C. 1. Escape schedule, silent period 20 seconds. Cumulative records from the 49th, 51st, and 53rd hours.

Figure 8. Rat C. 9. Escape schedule, silent period 10 seconds. Cumulative records for the 34th, 35th, and 36th hours on the schedule.

Analysis

Novel stimuli. Casual observation suggested that novel stimuli produced an increase in both the rate and regularity of responding for several minutes following the occurrence of the stimulus. To check this, the effects upon behavior of opening

Figure 9. Rat C.1. First record, escape schedule, silent period 20 seconds, the 27th hour. At the arrow (extinction) at the beginning of the next session the sound was continuously on. It remained on for the subsequent five daily sessions. The silent-period timer and reinforcement marker remained operative to keep all incidental relay and other noises constant.

the door of the experimental box, clapping the hands, or other mild novel stimuli were investigated. Stimuli of these kinds were applied to six animals at various points in the session. In five of these animals the novel stimulus was invariably followed by a period of regular rapid responding at a rate *higher* than that given at other times in the animal's history. In the sixth animal the effects of novel stimulation were confounded by the general pattern of responding of this animal (in bursts and pauses), and it was not possible to demonstrate the effects in a clear-cut manner. The effects of the novel stimulus when applied to two of these animals is shown in Fig. 10A and 10B. At the arrow the door of the experimental box was opened briefly, or a click was produced in the room. A short time later the animals gave a fine-grained and regular record which lasted until the end of the session. There are several points of interest in connection with these records. First, the fact that the animal immediately worked indicated that the low rates prevailing prior to the stimulation were not due to a decreased auditory sensitivity produced by the intense sound. Secondly, the effect was not produced by a sleeping animal being awakened by the stimulus, since the animal was working prior to the application of the stimulus. (See Fig. 10A.) Finally, the strength of responding following application of the stimulus exceeded that at other periods in the session, and indeed at any time in the animal's history.

These results suggested that the strength of the reinforcing stimulus complex supporting the escape behavior might be higher in the presence of novel stimuli than in a tightly controlled environment. With this in mind, two animals were run under

Figure 10. A. Rat X. 45. Escape schedule, silent period 20 seconds, 36th hour. A single click occurred at the arrow.

B. Rat X. 44. Escape schedule, silent period 20 seconds, 48th hour. The door of the experimental box was briefly opened at the arrow.

C. Rat X. 37. Escape schedule, silent period 20 seconds, 48th hour. At the arrow the door of the experimental box was opened and left open for the remainder of the session.

D. Rat X. 44. Escape schedule, silent period 20 seconds, 52nd hour. At the arrows the door of the experimental box was briefly opened.

two experimental conditions, each condition on alternate days. On one day the environment was tightly controlled and on the alternate day the door of the box was left open and the animal exposed to the general activity of the laboratory. On one animal the same two conditions were used, but the change occurred in the middle of a session. In all three animals, rates under the loosely controlled conditions were greater than those under tightly controlled conditions. One example of this is shown in Fig. 10C. At the arrow the door of the box was opened and remained open for the rest of the session. All other conditions remained the same. The improvement in behavior was immediate.

As might be expected, however, these effects were temporary, as shown in Fig. 10D. After a few days on the alternating conditions the behavior during the loosely controlled sessions became more like that during the well-controlled sessions, until finally there was little difference between them. Three additional animals were run, two under well-controlled conditions and one under loose control for the complete conditioning history of the animals. No systematic differences were found.

The reasons for the increase in response strength following the application of a novel stimulus remain obscure. The possibility that the novel stimulus raises the strength of all responding can be ruled out by the fact that responding during the silent period was *not* increased. The effect is probably related to the augmentation of some conditioned reflexes that occurs when a new member of a compound stimulus is first added (Pavlov, 1927, p. 73). This effect, in turn, is considered to be related to the augmentation of extinguished conditioned reflexes by weak novel stimuli (disinhibition). What is possibly a similar phenomenon in food based on behavior is illustrated in Fig. 310b in Ferster and Skinner (1957).

The Temporal Gradient of Onset of the Sound. The conventional analysis of escape behavior assumes that the strength of the escape response is dependent upon the termination of the sound (assumed to be a positively reinforcing event) and the delayed onset of the sound at the end of the silent period (assumed to be a negatively reinforcing event). This analysis suggests that the removal of the negatively reinforcing function of the onset of the sound may strengthen the response. The removal of this function might also be expected to produce, *inter alia*, an increase in the responding in the silent period.

To determine the effect of the onset of the sound the attempt was made to remove its negatively reinforcing function by making the onset gradual rather than abrupt. The equipment was modified so that the sound increased from zero to its maximum value over a period of 3 seconds at the end of the silent period.

Four animals were run on various arrangements of abrupt and gradual onset of the sound. In no case did the gradual onset condition change the behavior from that prevailing under the abrupt condition. Responding during the silent period was also unaffected. Data from one animal is shown in Fig. 11. These negative results are ambiguous, since the possibility remains that lengthening the duration of the onset was without effect upon its negatively reinforcing function.

The Temporal Gradient of the Termination of the Sound. The significance of the termination of the sound as a reinforcing stimulus was investigated by altering the mode of termination from abrupt to gradual. The equipment was modified so that a

Figure 11. Rat D.2. Escape schedule, silent period 20 seconds. A and B show the 36th and 37th hours under conditions of abrupt onset of the sound. C, D and E are the first, second and fourteenth sessions under conditions of gradual onset of the sound. The cumulative recorder stepped backwards. (See text.)

response was followed by a gradual reduction in the intensity of the sound over a 3-second period.

Four animals were exposed to various sequences of sessions of slow and abrupt termination of the sound. In every case the slow termination lowered the rate, increased response irregularity, and produced a warm-up effect at the beginning of the session. A return to the abrupt condition resulted in a slow recovery of the original behavior in two of the animals. In the remaining two the rate remained low and the animals showed virtually no recovery over a period of 31 sessions.

In Fig. 12 is shown the behavior of D.2. In A is shown the stable escape behavior of this animal after 12 hours on the schedule. In B are shown the ninth and tenth hours after the introduction of the slow termination of the sound. In C is shown the return to normal behavior by the second hour after restoration of abrupt termination. These results clearly indicated that sound termination was one component of the reinforcing complex which maintained escape responding. The explanation that the effects of slow termination of the sound were due to an effective delay of reinforcement appears unlikely, since the animal presumably would have formed chains to bridge the delay interval. However, an investigation of the effects of delay of reinforcement is necessary.

Effect of Amphetamine on Escape. The effect of 2 milligrams per kilogram of amphetamine sulphate upon stable escape responding was investigated in four animals. In three animals the rate of escape responding was at least tripled, while in the remaining animal the drug was without effect. The animal that failed to show

any change under the drug was responding at an extremely low rate prior to the administration of the drug, and it failed to give a single response during the drug session and for several sessions thereafter. Thus, a reinforcement was never received while the animal was under the influence of the drug, a fact which may account for the negative results. Typically, in those animals affected, the rate on the day following the drug was lower than normal, the animal reaching pre-drug rates by the second or third post-drug session.

In Fig. 13 is shown the effect of amphetamine on escape behavior. Record A shows stable behavior after 42 hours on the schedule. Record B shows the behavior during the session following A. The animal received 2 milligrams per kilogram of amphetamine sulphate 20 minutes prior to the session. Behavior during the following session is shown in C. The increase in rate produced by the drug is clear.

The effect of this drug on escape behavior was not further analysed. From the effects of the drug upon the termination-onset schedule, however, it is clear that the drug effect is *not* equivalent to increasing the intensity of the sound.

Duration of the Silent Period. While the foregoing data on the effects of varying the mode of termination of the sound suggest that termination is a reinforcing stimulus, this does not exclude the possibility that the duration of absence of the stimulus may also have a reinforcing function. To examine this possibility the duration of the silent period was varied.

Figure 12. Rat D. 2. Escape schedule, silent period 20 seconds.

A. The 12th hour under conditions of abrupt termination of the sound.

B. The 9th and 10th hours under conditions of slow termination of the sound.

C. The 2nd hour after the return to conditions of abrupt termination. The cumulative recorder stepped backwards. (See text.)

Figure 13. Rat C. 9. Escape schedule, silent period 10 seconds.

A. The 42nd hour.

B. The next session, amphetamine sulphate, 2 milligrams per kilogram, given 20 minutes before the start of the session.

C. The following session.

Five animals were exposed to silent periods (T_0) of various lengths. In all these animals the general patterning of responses as well as the over-all rate of escape responding were the same for duration of the silent period between 5 and 20 seconds. For one of the animals the silent period was reduced to 2 seconds. For the first series of sessions during which this duration was used (17 hours), the animal ceased to work during the last half of three-quarters of the session. Seventy-eight hours later, after the animal had been run on several other values of silent period, it was returned to a value of 2 seconds and gave a normal cumulative record.

In Table 1 is given the mean over-all escape response rate for the last seven sessions on each value of silent period, together with the standard deviation of the seven daily rates. *The data in the table are presented in the order in which they were gathered.* Inspection of the table reveals a trend in escape response rate during the experimental life of the animal (a total of 171 hours), but it can be seen that these rates were unrelated to the length of the silent period. Also shown in Table 1 is the mean number of responses per silent period (R). As would be expected, the number of responses decreased with a decrease in the length of the silent period. The mean for each value of T_0 is given in Table 2. The relationship between T_0 and responding in the silent period suggests that these responses tend to occur early in the silent period.

In an attempt to speed up the experimental work and also to avoid intersession variability, a sixth animal was run in a single 3-hour session on a range of values of the silent period between 1 and 20 seconds after receiving 2 milligrams per kilogram of amphetamine sulphate. This animal showed the high rates under the drug found

TABLE 1

Mean escape-response rate (responses per minute), its standard deviation, and mean number of responses per silent period (R) for different durations of silent period (T_0). The data are presented in the order in which they were collected. Animal C. 8.

T_0 (Seconds)	Mean Rate	S.D.	R
10	2.66	0.73	0.44
5	2.15	0.49	0.35
2	1.89	0.63	0.20
5	2.90	0.44	0.45
10	2.96	0.60	0.40
20	3.08	1.06	0.52
10	3.36	0.57	0.38
20	2.90	0.64	0.46
5	3.20	1.01	0.20
2	3.26	0.89	0.13

in other animals. As in the normal animals, there appeared to be no changes in escape response rate with changes in the length of the silent period. The data of this experiment are shown in Table 3. *Again, the data are given in the order in which they were collected*, each value of the silent period being given for 20 minutes. As in Table 1, a trend in over-all response rates can be seen running through the table, but there is no apparent relation between these rates and the length of the silent period. The relation between values of T_0 and the mean number of responses per silent period is given in Table 3. The mean value of these for each value of silent period is given in Table 4. These results agree with those of Table 2.

In summary, it appeared that the duration of the silent period above 1 second was not related to the amount of reinforcement of the preceding response. What the critical value of T_0 is, below which the reinforcing value of the silent period decreases, was not determined in this experiment. That this time interval is very short is indicated by the results obtained with the termination-onset schedule. (See

TABLE 2

Mean number of responses per silent period (R) for each duration of silent period (T_0). Animal C. 8.

T_0 (Seconds)	R
2	0.16
5	0.33
10	0.40
20	0.49

TABLE 3

Escape-response rate (responses per minute) and mean number of responses per silent period (R) for different durations of silent period (T_0) after the administration of 2 milligrams per kilogram of amphetamine sulphate. The data are presented in the order in which they were collected. Animal C. 9.

T_0 (Seconds)	Rate	R
10	13.0	0.82
5	19.3	0.87
2	22.2	0.42
10	23.1	0.63
2	15.8	0.38
5	16.7	0.61
10	11.1	1.16
1	10.2	0.30
5	10.9	0.43

below.) The measurement of the relationships between the duration of the silent period and response rates was greatly facilitated by the use of amphetamine, the whole function being collected in a 3-hour session in contrast to the 156 hours required to obtain the function in a normal animal.

Dinsmoor and Hughes (1956) and Dinsmoor, Hughes, and Matsuoka (1958) have shown that for values of the silent interval between 5 and 40 seconds there is, approximately, a linear relationship between the log, escape latency, and log T_0 (under both "press" and "release" conditions). The use of different stimuli together with many procedural differences between the present experiments and those of Dinsmoor make it uneconomical to speculate on the variables responsible for the difference in the T_0 functions obtained.

Time Between Sessions. Casual observation indicated that the time between sessions was a significant variable with respect to the strength of escape responding.

TABLE 4

Mean number of responses per silent period (R) for each duration of silent period (T_0) following the administration of 2 milligrams per kilogram of amphetamine sulphate. Animal C. 9.

T_0 (Seconds)	R
1	0.30
2	0.40
5	0.64
10	0.87

Five animals received lay-off periods of 22 to 28 months after reaching stable behavior. In four of these the number of responses during the first session after lay-off was much greater than during the last session prior to lay-off, for example, from 53 to 183 escape responses. To check this effect further, two animals were run daily until stable, laid off for a period of 10 days, and then run again until stable. Data from one of these animals are shown in Fig. 14. In A is shown the eleventh hour on the schedule. In B is shown the twelfth hour, taken after the 10-day lay-off period. By the fourth hour after the lay-off, shown in C, the behavior had returned to its original value. The second animal gave similar results.

One of the five animals that received a long lay-off period (25 months) failed to show an increase in response strength during the first post-lay-off session. The number of responses given during this session was normal for the animal. The reasons for this were not determined.

Termination-onset Schedule. As a means of checking the silent-period function reported above and also to investigate further the effects of termination and onset of the sound as reinforcing stimuli, five animals were run on the termination-onset schedule. An occurrence of R_P terminated the sound and an occurrence of R_R produced the sound. Stable behavior generated by 87 hours of this schedule is shown in Fig. 15A. The rate of R_R responding is low, the R_R response at "a," for example, did not occur for approximately 5 minutes after the preceding R_R (in contrast to an operant time of about 1 second). Of considerable interest is the fact that the escape behavior of this animal is similar to that obtained when it was run under the escape schedule. This is to be expected since in the Hefferline schedule

Figure 14. Rat C. 9. Escape schedule, 10-second silent period.

A. The 11th hour on the schedule.

B. The 12th hour taken 10 days after A.

C. The fourth hour after B, the sessions were spaced daily. The cumulative recorder stepped backwards. (See text.)

Figure 15. Rat C. 5.

A. Termination-onset schedule, 2-hour session after 87 hours on the schedule.

B. Escape schedule, silent period 10 seconds, 2-hour session after 18 hours on this schedule.

the majority of values of T_O are in excess of the lowest value used in the escape schedule. To illustrate further the similarity of escape responding under the two schedules, this animal was run under the escape schedule with a silent period of 10 seconds. In Fig. 15B is shown a whole session after 18 hours on the schedule. A visual comparison of temporal distribution of escape responses in Fig. 15A and B reveals their similarity under the two conditions. In other words, and as suggested by Hefferline, R_P and R_R were two distinct responses independently controlled by their reinforcing stimuli.

One further aspect of the Hefferline schedule is also shown in Fig. 15A. Rate of escape responding tended to remain fairly constant throughout the session, whereas the rate of R_R showed a progressive decrease during the first 15 to 20 minutes of the session. Since there were presumably avoidance responses (Winnick, 1956; Hefferline, 1950) occurring between occurrences of R_R , this warm-up was probably related to the warm-up reported in Sidman (1953) avoidance schedules. The Hefferline schedule clearly showed that warm-up was limited to avoidance responding and was without effect upon concurrent escape behavior.

It has been shown that the abrupt termination of the sound supported a higher response rate than a slow termination. To determine whether the effect of slow sound termination was limited to escape responding and without effect upon the R_R responses, three animals were run on the Hefferline schedule with comparison of abrupt and slow termination of the sound. On the basis of the two responses being independently determined, it is to be expected that the slow termination of the sound will decrease the rate of escape responding without having any effect upon the rate of R_R . Rate changes of the two responses were as expected. Cumulative records from one of these animals is shown in Fig. 16. In A is shown typical behavior under abrupt termination conditions. In B is shown the effect of slow termination of the sound after 4 hours on this schedule. The reduced number of

Figure 16. Rat C. 6. Termination-onset schedule.

A. The 24th-hour run under conditions of abrupt termination of the sound.

B. The 5th hour of slow termination of the sound.

C. The 5th hour after return to abrupt termination of the sound.

The cumulative recorder stepped backwards. (See text.)

responses is apparent. In C is shown the behavior 5 hours after abrupt termination was restored; C is similar to A.

Rates of R_p and R_R for this animal over the periods of change of the termination conditions are given in Table 5. As can be seen, slow termination decreased the rate of R_p while having no effect upon the rate of R_R .

The effects of amphetamine sulphate (2 milligrams per kilogram) upon behavior generated by the termination-onset schedule was examined in one animal. Cumulative records are shown in Fig. 17. In A is shown behavior during the session prior to the administration of the drug. In B is shown the first half-hour of the session under the drug. As would be expected from the records shown above (Fig. 13), the rate of escape responding was increased. The rate of R_R was also increased. This result clearly showed that the effect of the drug was not equivalent to increasing the intensity of the sound. Rates of the two responses for the pre-amphetamine and the amphetamine session are given in Table 6.

Figure 17. Rat C. 6. Termination-onset schedule.

A. After 25 hours on the schedule.

B. The following session, after 2 milligrams per kilogram of amphetamine sulphate.

TABLE 5

R_p and R_R rates (responses per minute) for successive sessions under conditions of abrupt and slow termination of the sound. Animal C. 6.

Date	R_p rate	R_R rate	Condition
10-8	3.46	2.89	Abrupt termination
10-9	3.84	4.31	
10-10	2.35	2.43	
10-11	1.93	2.69	
10-12	0.85	2.76	
10-13	1.06	4.22	Slow termination
10-14	0.50	6.38	
10-15	1.58	2.69	
10-16	1.06	3.82	
10-17	0.62	3.20	
10-18	2.29	1.76	Abrupt termination
10-19	2.91	6.52	
10-20	2.16	2.58	
10-21	3.77	2.51	
10-22	3.26	3.12	
10-23	2.58	2.88	
10-24	3.07	2.38	
10-25			
10-26	4.34	3.38	

In a recent study of the effects of sound on behavior, Barnes and Kish (1957) ran one experimental group of animals on a termination-onset schedule and reported in their results only the total time the sound was off (the time the animals spent on the platform). They interpret these results as demonstrating that the termination of the sound was controlling the behavior. From the foregoing comments on the Hefferline schedule, it is clear that total time in silence is ambiguously related to sound termination. Only if the rate of escape responding (which is independent of the time the sound is off) undergoes a progressive increase is termination directly implicated as a possible reinforcing stimulus. A progressive increase in total time the sound is off may simply reflect a progressive decrease in the rate of R_R (leaving the platform), with no change in escape rate from the operant value. The same comments may also be applied to a paper by Campbell (1955).

TABLE 6

Effect of amphetamine sulphate (2 milligrams per kilogram) on R_p and R_R response rates (responses per minute). Animal C. 6.

Date	R_p rate	R_R rate	Condition
11-7	4.61	2.72	Normal
11-10	22.7	12.4	Amphetamine

SUMMARY

Noise was used as the aversive stimulus in escape (Keller) and termination-onset (Hefferline) schedules. Two operants were instrumented: R_P , the depression of a Gerbrands rat lever, and R_R , the return of the lever to its normal position. In both schedules an occurrence of R_P terminated the sound. In the termination-onset schedule, an occurrence of R_R turned on the sound; this response was without contingency in the escape schedule.

Behavior developed more slowly and attained a lower stable over-all rate on the sound-escape schedule than is reported for behavior under light and shock escape.

Momentary novel stimuli greatly increased the local rate. The continuous application of novel stimulation maintained the rate for several sessions at values well above that previously attained by the animal in its prior history on the schedule.

A gradual termination of the sound was associated with a lower over-all rate of R_P in both schedules than was the normal abrupt termination of the sound.

Amphetamine was found to increase the over-all rate of R_P , in both schedules, by a factor of at least two to one. In the Hefferline schedule the over-all rate of R_R was increased by a factor of four to one.

Variation of the silent period between 2 and 20 seconds was without effect upon the over-all rate of R_P in the escape schedule.

The over-all rate of R_P (in the escape schedule) was increased by a factor of three to one by a lay-off period of approximately 2 years. Shorter lay-off periods (1 week) were also found to increase the rate.

In the Hefferline schedule, R_P showed no consistent change in rate during a session, while R_R showed a warm-up effect over the first 20 minutes of the session.

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