QUASI-REINFORCEMENT: CONTROL OF RESPONDING BY A PERCENTAGE-REINFORCEMENT SCHEDULE¹

ALLEN J. NEURINGER² AND SHIN-HO CHUNG

HARVARD UNIVERSITY

When a variable-interval schedule of reinforcement was segmented into small fixed-interval components, with reinforcements following some components and brief blackouts following the others, rate of responding doubled and a positively accelerated pattern within each component was obtained. Presented according to this percentage reinforcement paradigm, the blackouts approximated the functions of a food reinforcer. These effects occurred only when the behavior sequence required to produce reinforcement was identical to that required to produce blackout. The quasi-reinforcing effects of these blackout stimuli suggest that a neutral stimulus need not occasion or accompany a primary reinforcer to acquire reinforcing properties.

Ferster and Skinner (1957) showed that a pigeon's performance under a fixed-ratio schedule (FR) was sustained when food reinforcements were intermittently replaced by long periods of blackout. The term "percentage reinforcement" was used to describe the schedule in which a fixed number of responses sometimes produced food and sometimes produced blackout. Since the blackouts replaced, rather than preceded, the primary reinforcer, the conditions necessary to establish a secondary reinforcer were not satisfied. Yet, the pattern of responding found on a regular ratio schedule was maintained. Similar effects were reported by Zimmerman (1960). These results suggest that a neutral stimulus might acquire reinforcing attributes by means of a paradigm other than the one customarily used to establish a secondary reinforcer.

Subsequent studies employing percentage-reinforcement schedules have confounded the effects of percentage reinforcement and the effects of secondary reinforcement (Findley and Brady, 1965; Kelleher, 1966; Thomas and Stubbs, 1966). In these studies, a previously neutral stimulus was both presented according to a percentage-reinforcement schedule and paired with primary reinforcement. Although Kelleher's experiments (1966) showed that the reinforcing effects of the neutral stimulus de-

pended upon its being paired with primary reinforcement, the percentage-reinforcement schedule itself might exert considerable control over behavior. The present experiments were designed to study the extent of this control. Pigeons were initially trained to respond for food reinforcement on a variable-interval (VI) schedule. Without changing the programmed rate of primary reinforcement, the schedule was then segmented into small fixed-interval (FI) components, with reinforcements following some components and brief blackouts following the others. Control experiments were performed to determine the necessary conditions for the reinforcing effects produced.

METHOD

Subjects

Three male White Carneaux pigeons, with previous experience in a variety of experiments, were maintained at approximately 80% of their free-feeding body weights throughout the experiment.

Apparatus

A standard experimental chamber for the pigeon contained a translucent response key, mounted 26 cm above the floor on a vertical aluminum panel. A feeder which gave 3-sec access to food reinforcement was located 13 cm directly below the response key. The chamber was illuminated by a white overhead light and, except when the feeder was operating, the response key was transilluminated by a 7 w red

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²A National Science Foundation Pre-doctoral Fellow.

bulb. A peck of at least 10 g force was recorded and produced a feedback click from a dc relay mounted behind the panel. White masking noise was continuously present. All sessions were terminated after 55 reinforcements.

EXPERIMENT I

Procedure

The subjects were given preliminary training on a variable-interval schedule of reinforcement with an average interval of 1 min (VI 1). The interreinforcement intervals were: 60, 100, 5, 133, 147, 23, 25, 7, 60, 30, and 70 sec. The schedule was then segmented into a series of *tand* FR 1 FI 5-sec components, with reinforcements occurring only a percentage of the time. On this schedule, a peck initiated a 5-sec interval; the first peck to occur after this interval terminated the component by producing either a food reinforcement or a 1-sec period during which the experimental chamber was totally dark (1-sec blackout). During blackouts, pecks did not produce feedback clicks. Virtually no responses were emitted in these blackout periods. The VI programmer, which was the same as used during preliminary training, operated throughout the session except when it had primed and when reinforcements and blackouts were presented. If the VI programmer had primed, a component would end with a response-produced reinforcement. If the VI programmer had not primed, the same component would end with a response-produced blackout. After either reinforcement or blackout, a peck initiated another 5-sec interval. Because the reinforcement programmer was inactivated during blackout periods, and because a reinforcement could occur only at the end of a component, the average interreinforcement time was slightly longer than during preliminary VI training. Under these conditions, just as under variable-interval schedules, rate of responding had an insignificant effect on rate of reinforcement. Effectively, the above schedule is a *tand* FR 1 FI 5-sec with independently programmed reinforcements occurring only a percentage (approximately 15%) of the time. It will be referred to as a percentage-reinforcement, or PR, schedule, a diagram of which is shown in Fig. 1.

After 22 sessions of exposure on the percentage-reinforcement schedule with 1-sec blackouts, the original VI 1 schedule was reinstated for 13 sessions. The subjects were then placed

Fig. 1. A schematic illustration of the contingencies of reinforcement and blackout under a percentage-reinforcement (*tand* FR 1 FI 5-sec) schedule.

on the same PR schedule with 7-sec blackouts replacing the 1-sec blackouts and, after a return to the VI 1, the blackout duration was decreased to 0.25 sec.

Performance under a regular *tand* FR 1 FI 5-sec (100% reinforcement) schedule was obtained after all the subsequent experiments were completed. Under this schedule, no blackouts occurred; a reinforcement was presented after each *tand* FR 1 FI 5-sec component.

Results

Figure 2 shows the individual daily performances of the three subjects on the variable-interval schedule and the percentage-reinforcement

Fig. 2. The daily, individual rates of responding under variable-interval and percentage-reinforcement (*tand* FR 1 FI 5-sec) schedules.

schedule with 1-sec blackout. The points in Fig. 2, and in subsequent figures, were obtained by dividing the total number of responses emitted during the session by the session time. The few responses emitted during periods of blackout and reinforcement, and the time comprising these periods, were excluded from the rate calculations. The rates of responding on the percentage-reinforcement schedule increased gradually from the baseline VI response rates and attained stable levels. The average of the terminal rates of responding on the percentage-reinforcement schedule (106 responses per min), obtained by averaging the performances of the last five sessions, was approximately twice the average rate on the VI schedule (51 responses per min). The percentages of reinforced components over the last five sessions were 18.6%, 15.7%, and 13.2% for subjects 280, 281, and 282, respectively. The individual rates of responding and the averaged rate across subjects under the present

and following schedules are presented in Table 1.

When the 1-sec blackout was replaced first by a 7-sec blackout and then by a 0.25-sec blackout, the average rates of responding obtained were 129 and 110 responses per min, respectively. Performances under both these conditions are shown in Fig. 3. The average terminal VI response rates preceding the PR schedules are indicated by horizontal lines. A close inspection of Fig. 3 indicates that the 7-sec blackout produced faster acquisition of percentage-reinforcement performance and greater day-to-day variability than did either the 0.25-sec or 1-sec blackout. Although an increase in blackout duration from 1 to 7 sec increased rate of responding, the rate also increased when 0.25-sec blackout was used. It thus appears that the enhancement in rate of responding due to the PR schedule is not appreciably influenced by blackout durations within the range explored here.

Table 1

Experiment	Schedule	Rate of Responding			Average Rate	Average Sessions Run
		280	281	282		
I	VI 1	65	43	46	51	16
	PR: <i>tand</i> FR 1 FI 5-sec 1-sec blackout	91	115	114	106	22
	VI 1	82	51	48	61	13
	PR: <i>tand</i> FR 1 FI 5-sec 7-sec blackout	134	137	115	129	22
	VI 1	81	61	53	65	10
	PR: <i>tand</i> FR 1 FI 5-sec 0.25-sec blackout	116	97	117	110	23
II	PR: <i>tand</i> FR 1 FI 5-sec no blackouts	52	50	51	51	14
III	PR: <i>tand</i> FR 1 FI 5-sec 1-sec key light off (280, 281) 1-sec buzzer (282)	132	118	114	121	21
	VI 1; non-contingent 1-sec blackouts occur every 11 sec	67	62	53	60	20
IV	VI 1; 1-sec blackouts occur every eleventh peck	79	53	73	69	23
	PR: FR 11; 1-sec blackout	107	124	132	121	48
I	<i>tand</i> FR 1 FI 5-sec 100% reinforcement	136	105	145	129	32

The individual rates of responding, the average rates across subjects, and the average number of sessions for each of the schedules. Rates of responding were obtained by averaging the performance during the last five sessions under each schedule.

The regular *tand* FR 1 FI 5-sec (100% reinforcement) schedule produced a response rate of 129 responses per min. The rate of reinforcement under this condition, computed by dividing the number of obtained reinforcements by the time that the key light was on, was 6.9 reinforcements per min, as compared to 0.9 reinforcements per min under the percentage-reinforcement (1-sec blackout) schedule. This eight-fold increase in reinforcement rate only slightly increased rate of responding. On the other hand, when the rate of reinforcement was kept approximately constant, a change in schedule from VI to percentage reinforcement more than doubled rate of responding.

The pattern of responding produced by the percentage-reinforcement conditions was similar to that produced by the regular *tand* FR 1 FI 5-sec (100%) condition, as shown in Fig. 4 and 5. Figure 4 shows enlarged sections from the cumulative records of subject 281 under the VI, PR (1-sec blackout), and *tand* FR 1 FI 5-sec (100%) conditions. The record at the right of Fig. 4 shows the characteristic performance under a *tand* FR 1 FI 5-sec schedule: a brief pause after reinforcement is followed by a period of rapid responding. These same

Fig. 4. Enlarged sections from selected cumulative records for subject 281. The record displayed at left is obtained from a variable-interval schedule, at center from a percentage-reinforcement (*tand* FR 1 FI 5-sec) schedule using 1-sec blackouts, and at right from a regular *tand* FR 1 FI 5-sec (100% reinforcement) schedule. The small diagonal marks denote reinforcements.

characteristic features appear in the PR record. Selected cumulative records obtained from subject 281 under the present and some of the following schedules are shown in Fig. 5. The records at right are enlarged segments.

Fig. 5. Selected cumulative records for subject 281. The records displayed at right are enlarged segments. Reinforcements are indicated by the small downward marks.

Fig. 3. The daily rates of responding under a percentage-reinforcement (*tand* FR 1 FI 5-sec) schedule using 7-sec blackouts and 0.25-sec blackouts to replace reinforcements. The horizontal lines show the average of the terminal rates of responding under the preceding variable-interval schedules.

Both rate and pattern of responding produced by the percentage-reinforcement schedule were similar to the rate and pattern of responding produced by the *tand* FR 1 FI 5-sec (100%) schedule. Thus, the blackout stimulus, when presented on a PR schedule, appears to approximate the function of a primary reinforcer.

EXPERIMENT II

Procedure

Since the rate and distribution of primary reinforcement on both VI and percentage-reinforcement schedules were similar, the doubling in rate of responding and the change in pattern of responding produced by the PR schedule are noteworthy. Each of the following experiments is an attempt to specify the necessary conditions for these effects. First, to determine whether the contingencies of primary reinforcement occurring on the PR schedule caused the changes in rate and pattern of responding, the blackouts were eliminated while leaving the PR schedule otherwise intact.

Fig. 6. The daily rates of responding under a percentage-reinforcement (*tand* FR 1 FI 5-sec) schedule in which the blackouts were omitted. The contingencies of reinforcement were identical to those under the percentage-reinforcement schedule in Exp I. The upper horizontal line shows the average of the terminal rates under the percentage-reinforcement schedule, and the lower horizontal line shows the average rate under the variable-interval schedule.

As in Exp I, a single peck initiated a 5-sec interval. The first peck to occur after this interval was reinforced only if the VI programmer had primed before this response was emitted. If the programmer had not primed, the same peck caused no differential stimulus change, and the next peck initiated another 5-sec interval. Reinforcements were programmed by the same VI 1 programmer used in Exp I. The contingencies of primary reinforcement on this schedule were identical to those on the PR schedule. The only difference was that no blackouts occurred on the present schedule.

Results

When the brief blackouts were eliminated from the PR schedule, the rates of responding decreased rapidly from the previous PR performance levels, as shown in Fig. 6. The average of the terminal rates of responding on the present schedule (51 responses per min) was equal to that on the original VI 1 schedule (see Table 1 and Fig. 5). The pattern of responding was similar to that observed on the VI schedule. These findings indicate that the rate and pattern of responding observed under the percentage-reinforcement schedule were not due to the contingencies of primary reinforcement alone.

EXPERIMENT III

Procedure

The percentage-reinforcement schedule enhanced rate and changed pattern of responding when blackouts occurred at the end of unreinforced components. When such exteroceptive stimuli were absent, these effects were not obtained. It was subsequently found that these same percentage-reinforcement effects could be obtained when the 1-sec blackout was replaced by a 1-sec period during which only the key light was turned off, with the house light remaining on, or by an auditory stimulus (buzzer) of the same duration, with both key and house lights always remaining on (see Table 1). Having returned the subjects to a PR schedule, the question then considered was whether the intermittent presentation of an exteroceptive stimulus, occurring independently of the subjects' behavior and without any systematic relation to the occurrences of reinforcement, was a sufficient condition to maintain PR effects.

Responding was reinforced according to the same variable-interval schedule used in each of the previous experiments. Superimposed on this schedule, however, were 1-sec blackouts which occurred every 11 sec and were presented independently of the subjects' responses. An 11-sec interval was used so that the rate and total number of blackouts occurring under this condition would be approximately equal to those under the percentage-reinforcement (1-sec blackout) schedule. The timer which programmed the blackouts was inactivated during reinforcement, and the VI programmer was inactivated during blackout. Consequently, there was no systematic relation, either in time or in responding, between the occurrences of blackouts and reinforcements.

Results

Although the number of blackouts per session was approximately equal to the number presented on the PR schedule, the rates of responding decreased from the PR performance levels, as shown in Fig. 7. The average of the terminal rates of responding was 60 responses per min, a rate only slightly higher than the

average of the rates of responding during the original VI 1 training (51 responses per min). The pattern of responding was similar to that observed on the VI schedule (see Fig. 5). The periodic presentation of 1-sec blackouts, when not contingent upon responding and independent of primary reinforcement, did not enhance rate of responding or produce the positive acceleration obtained on the PR schedule.

EXPERIMENT IV

Procedure

The previous experiments showed that neither the schedule of primary reinforcement occurring under the PR schedule nor the presence of independently programmed blackout periods was a sufficient condition for the PR effects. The present experiment attempts to determine whether it was the schedule of blackouts, rather than the schedule of primary reinforcement, which produced these effects. To do this, two conditions were compared in which the schedules of blackouts were the same. In the percentage-reinforcement condition, however, the behavior sequence required to produce primary reinforcement was identical to that required to produce blackout; in the control condition, this was not the case.

Whereas in the previous percentage-reinforcement study a *tand* FR 1 FI 5-sec response requirement produced either reinforcement or blackout, the present PR schedule used an FR 11 response requirement. Every eleventh response produced either a 1-sec blackout or primary reinforcement, depending upon whether the VI programmer had primed before each eleventh response was emitted. Thus, the behavior required for the presentation of reinforcement (11 consecutive pecks) was identical to that required for the presentation of blackout (11 consecutive pecks). Reinforcements were programmed by the same VI 1 schedule used in each of the previous experiments.

In the control condition, blackouts were again presented on an FR 11 schedule. In contrast to the PR schedule, however, the first peck to occur after the VI programmer had primed produced primary reinforcement. Thus, the behavior required for the presentation of blackout (11 consecutive pecks) was not the same as that required for the presenta-

Fig. 7. The daily rates of responding under a schedule in which 1-sec blackouts were presented every 11 sec independent of the subjects' behavior. Primary reinforcement was presented on a VI 1 schedule. The horizontal line shows the average of the terminal rates of responding under the variable-interval schedule.

tion of reinforcement (a single peck). If the VI programmer had primed just before the eleventh response emitted in a sequence, the response would produce reinforcement rather than blackout. The next response would then produce the blackout. Effectively, the control study employs two superimposed schedules: a VI 1 schedule for primary reinforcement and an FR 11 schedule for 1-sec blackout. An FR 11, rather than a *tand* FR 1 FI 5-sec schedule, was used in the present studies to decrease the likelihood that the subjects' pausing behavior, when under the control condition, would result in an accidental identity between the behavior sequences leading to blackout and reinforcement.

Results

The individual daily performances for the three subjects under PR and control conditions are shown in Fig. 8. Whereas the average of the terminal rates of responding under the control condition was 69 responses per min, the average rate under the PR condition was 121 responses per min. The difference in rate of responding between the control and the PR conditions is least conspicuous for subject 280. This is due to this subject's long pausing after blackout when on the PR schedule (see Fig. 9). The pattern of responding under the control condition was similar to the behavior under the VI schedule (see Fig. 5). However, as shown in Fig. 9, typical fixed-ratio behavior was obtained from the PR schedule. The average interresponse times between each of the 11 responses under the PR condition are plotted. The first point plotted is the average pause after blackout, *i.e.*, the time between the end of the blackout stimulus and the first response. As is found on a regular fixed-ratio schedule (100% reinforcement), a long pause before the first response in a sequence is followed by rapid responding. Thus, when an FR 11 led to either blackout or primary reinforcement, with reinforcement occurring on the average of once a minute, a high rate of responding and positively accelerated pattern of responding were found. On the other hand, when blackouts were presented on an FR 11 schedule while primary reinforcement occurred on a regular VI 1 schedule, neither of the PR effects was found. Since the schedules of blackouts were identical in the PR and control studies, the results demonstrate

Fig. 8. The daily rates of responding under a percentage-reinforcement schedule and under a control schedule. In the percentage-reinforcement schedule, an FR 11 response requirement resulted either in 1-sec blackout or in primary reinforcement, with primary reinforcements occurring on the average of once a minute. In the control schedule, an FR 11 response requirement resulted in 1-sec blackout while primary reinforcement was presented on a regular VI schedule.

Fig. 9. The average interresponse times between each of the 11 responses under a percentage-reinforcement (FR 11) schedule. The first point plotted is the average time between the end of the blackout stimulus and the occurrence of the first response. The 11 interresponse times following each reinforcement were excluded from these calculations.

that the blackout schedule alone cannot produce the PR effects.

Although no control experiment was performed, it is unlikely that the present PR effects would be produced if the brief blackouts following every unreinforced eleventh response were eliminated. It was shown in Exp II that occurrences of blackouts at the end of each *tand* FR 1 FI 5-sec component were essential to produce the PR effects. In view of these findings, it is unlikely that the contingencies of primary reinforcement are responsible for the present PR effects.

DISCUSSION

Stimuli other than primary reinforcers often control behavior. While maintaining a constant rate and distribution of primary reinforcement, the rate and distribution of responding in a free operant situation can be manipulated by, for example, presenting secondary reinforcers or establishing "behavioral contrast" conditions. Because most behavior is preceded by, emitted in the presence of, or followed by stimuli which are not primary reinforcers, it is necessary to specify the operations by which previously neutral stimuli come to control behavior, and to specify the kind and extent of the control exerted.

The present experiment examines the control exerted by a percentage-reinforcement (PR) schedule. Under this schedule, a required behavior sequence is sometimes followed by primary reinforcement and sometimes followed by blackout. No differential cues distinguish which of the two stimuli will follow any given behavior sequence. When the behavior emitted under two PR schedules was compared to that emitted under a variety of control conditions, with rate of primary reinforcement approximately the same in all studies, the PR schedules were found to double rate of responding and to change the pattern of responding. Both pattern and rate under PR conditions were similar to those under a schedule in which the same behavior sequence always resulted in primary reinforcement.

The necessary condition for the effects produced by the PR schedule appears to be an identity between the required behavior sequence leading to primary reinforcement and the required behavior sequence leading to blackout. Under the PR schedule in Exp I, the required behavior sequence producing either primary reinforcement or blackout consisted of two non-contiguous responses, separated by an interval of at least 5 sec (*tand* FR 1 FI 5 sec). Under the PR schedule in Exp IV, the required behavior sequence consisted of 11 consecutive responses (FR 11). When the required behavior sequence producing reinforcement was identical to that producing blackout, with reinforcements and blackouts occurring in random order, the changes in overall rate and in pattern of responding were obtained. The PR effects were not produced by either the schedule of primary reinforcement (Exp II), the number and distribution of blackout stimuli (Exp III), or the schedule of blackout stimuli (Exp IV) occurring under the percentage-reinforcement conditions.

The blackouts presented on a PR schedule appear to exert reinforcing control over behavior. First, the blackouts produced an overall increase in rate of responding. Second, with increasing proximity to the contingent stimulus (either primary reinforcement or blackout), there was an increase in the probability of a response. When a *tand* FR 1 FI 5-sec was sometimes followed by a food reinforcement (about 15% of the time) and other times by a 1-sec blackout, the pattern of responses emitted resembled that on a regular *tand* FR 1 FI 5-sec

(100%) schedule. Effectively, the blackout approximated the function of a food reinforcer when the former intermittently replaced the latter. The blackouts can, therefore, be considered quasi-reinforcers. These same reinforcing effects were obtained when the blackout was replaced by either a 1-sec period of key light off (with house lights remaining on), or by a 1-sec buzzer (with both key and house lights remaining on).

The reinforcing effects obtained from a previously neutral stimulus which is presented on a percentage-reinforcement schedule thus appear to be similar to some of the effects obtained from a secondary reinforcer (*e.g.*, Kelleher and Gollub, 1962). If a secondary reinforcer is defined in terms of its effects on behavior, the neutral stimuli used in the present study can be said to have acquired some of the properties of the secondary reinforcer. There is an important difference, however, between the experimental operations by which a secondary reinforcer is usually defined (*e.g.*, Keller and Schoenfeld, 1950; Kimble, 1961; Kelleher and Gollub, 1962) and those operations which produce the percentage-reinforcement effects. Secondary reinforcers are established by presenting a neutral stimulus at the same time as, or immediately before, a primary reinforcer. The close temporal pairing of the two stimuli, neutral and reinforcing, operationally defines the secondary reinforcer. On the other hand, the previously neutral stimulus presented on a PR schedule never occurs at the same time as, or immediately before, the primary reinforcer. Whereas the secondary reinforcer is defined by a close temporal relationship between it and the primary reinforcer, the quasi-reinforcer is defined by an identity between its relation to behavior and the relation of the primary reinforcer to behavior. And whereas the secondary reinforcer denotes the occurrence of, or availability of, the primary reinforcer, the quasi-reinforcer denotes the non-occurrence of the primary reinforcer. It then can be concluded, on the basis of the present findings, that a neutral stimulus does not necessarily have to occasion or accompany a primary reinforcer in order to acquire reinforcing properties of its own. Whether the quasi-reinforcer can produce all the effects produced by the secondary reinforcer, *e.g.*, delay of extinction, conditioning of some new response, and chaining effects

(Kelleher and Gollub, 1962), is an experimental question presently being considered.

Although the interpretation offered has been that the PR effects were due to an identity between the required behavior sequences leading to blackouts and reinforcements, some other interpretations will briefly be considered. (1) It is conceivable that "trace conditioning" (Pavlov, 1928) occurred between the blackout stimuli and the food reinforcers. In Exp III and the control portion of Exp IV, however, blackouts were often temporally closer to the food reinforcers than when under the PR schedules, and PR effects were not found. It is thus unlikely that a closeness in time between blackout and food stimuli will account for the present results. (2) The PR paradigm is closely related to the "temporal conditioning" paradigm (Pavlov, 1928) used in classical conditioning. During temporal conditioning, a fixed time interval separates repeated presentations of an unconditioned stimulus. If the unconditioned stimulus is occasionally omitted, a conditioned response occurs at the time that the unconditioned stimulus would have been presented. Thus, just as under a percentage-reinforcement schedule, the animal responds as if a reinforcing stimulus were to be presented. However, whether temporal conditioning can account for the PR effects, or whether the PR paradigm can account for temporal conditioning is a question unresolved by the present work. (3) Although the number of blackouts preceding food reinforcement varied throughout the session, an increase in the number of consecutive blackouts was correlated with an increase in the probability that the next stimulus change would be a food reinforcer. Thus, the number of consecutive blackouts might have acted as a discriminative stimulus for reinforcement, and the blackouts might thereby have acquired reinforcing properties. This interpretation is implausible because the same relationship between number of consecutive blackouts and food reinforcement existed in Exp III and the control portion of Exp IV. The PR effects were not obtained in either of these cases. (4) A similarity between the PR effects and Amsel's "frustration effect" (Amsel and Roussel, 1952; Staddon and Innis, 1966) should be noted. Rats run faster from the first to the second of two serial goal boxes on those trials in which reinforcement is not presented

in the first box. The increase in running speed due to the omission of reinforcement might be analogous to the increase in rate of responding due to blackouts presented under a PR schedule. To the extent that the two phenomena are similar, Amsel's theoretical notions (Amsel, 1958) might apply to the present work.

The present findings indicate that there are previously neutral stimuli other than secondary reinforcers which control intermittently reinforced behavior. When, with no differential cues present, a single required behavior sequence sometimes produces primary reinforcement and sometimes produces a neutral stimulus, the necessary conditions for establishing the neutral stimulus as a quasi-reinforcing stimulus are met. These conditions are satisfied by all intermittent schedules of primary reinforcement in which no differential cues precede the presentation of reinforcement (*e.g.*, a variable-interval or variable-ratio schedule). On such a schedule, the required behavior sequence is the single effective response; this response sometimes produces a neutral stimulus (*e.g.*, feedback click) and sometimes produces primary reinforcement. Thus, the quasi-reinforcing properties of the PR stimulus might help to explain the control and maintenance of many intermittently reinforced responses.

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