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EFFECTS OF STIMULUS DURATION ON OBSERVING BEHAVIOR MAINTAINED BY DIFFERENTIAL REINFORCEMENT MAGNITUDE[1]

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Pigeons made observing responses for stimuli signalling the availability of either 10-sec or 2-sec access to grain on fixed-interval 1-min schedules. If observing responses did not occur, food-producing responses occurred to a stimulus common to both reinforcement magnitudes. When the stimuli remained on for the duration of the components and signalled differential reinforcement magnitudes, observing responses were maintained; however, when the stimuli remained on for 10 sec, observing responses decreased markedly. In addition, it was shown that the occasional presentation of the stimulus signalling 10-sec access to grain was necessary for the maintenance of observing behavior. A control condition demonstrated that when all the available stimuli signalled 6-sec access to grain, observing responses declined. Taken together, the results demonstrated that the occasional presentation of the stimulus that remained on for the duration of the component and signalled the larger reinforcement magnitude was necessary for the maintenance of observing behavior.

An observing response is any response that results in exposure to a discriminative stimulus (Wyckoff, 1952). Typically, such a response converts a mixed schedule of reinforcement into a multiple schedule, thus producing a specific stimulus signalling the component schedule arranged at that particular time (Wyckoff, 1952, 1969; Kelleher, Riddle, and Cook, 1962). If an observing response does not occur, the reinforcement contingencies are not altered and the organism behaves in the presence of a stimulus common to the various components, *i.e.*, a mixed schedule. Hence, in the observing response procedure, the actual reinforcement contingencies are not controlled by the organism but the stimulus in the presence of which the organism behaves is under the organism's control.

Previous free-operant studies of observing behavior have employed schedules generating differential reinforcement rates (Kendall, 1965*a*, 1965*b*, 1968, 1969; Kendall and Gibson, 1965; Hendry, 1969*b*; Branch, 1970), while reinforcement magnitude, another traditional reinforcement parameter (Kimble, 1961) has received no attention. Relatedly, several recent studies have suggested the effects of varied reinforcement magnitude in multiple schedules (Shettleworth and Nevin, 1965; Keesey and Kling, 1961) and in concurrent schedules (Brownstein, 1971; Neuringer, 1967; Catania, 1963*b*, Rachlin and Baum, 1969) are functionally similar to the effects of varied reinforcement rate (Herrnstein, 1964, 1970, Catania, 1963*a*). The following experiment investigated the effects of differential reinforcement magnitude in an observing response paradigm where reinforcement rate was held relatively constant. In addition, a number of studies (*e.g.*, Kendall, 1965*b*) have shown that when reinforcement rate is a variable, the duration of the stimulus that follows an observing response may be relatively brief (10 sec or shorter) and still maintain observing behavior, even though the stimulus is seldom, if ever, contiguous with primary reinforcement. In the present experiment, therefore, the duration of the stimulus that followed an observing response was 10 sec in one condition and the duration of the component in another condition.

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EXPERIMENT I: STIMULUS DURATION

METHOD

Subjects

Three adult male White Carneaux pigeons were maintained between 75 and 80% of their free-feeding weight throughout the experiment. P28 and Y72 had served in observing response experiments for differential rates of reinforcement, and P11 in experiments using auto-shaping procedures and fixed-interval (FI) and fixed-time (FT) schedules of reinforcement.

Apparatus

A standard (Lehigh Valley Electronics, Model 1519a) two key pigeon chamber was housed in a sound-attenuating chamber. A minimum force of approximately 15 g (0.15 N) was required to operate each key. Experimental conditions were arranged by conventional relay and timing circuitry. White masking noise was continuously present. Data were recorded on digital counters and a Gerbrands cumulative recorder.

Procedure

Multiple schedule training. P11 was given eight days of training on an FI 1-min schedule where reinforcement consisted of either 10-sec or 2-sec access to mixed grain. Components that terminated in 10-sec access to grain were signalled by a red lighted key (R10); the 2-sec access to grain components were signalled by a green lighted key (G2). Schedule components alternated at random, after reinforcement, with the restriction that no more than three of the same components could occur in succession. Technically, this schedule will be referred to as a *mult* (10-sec 2-sec). Because P28 and Y72 had been exposed to similar contingencies in a previous experiment, they were not exposed to the preliminary multiple schedule training P11 encountered; however, at various points in the procedure all three birds received *mult* (10-sec 2-sec) schedule training.

Table I lists the sequence of experimental conditions and the total number of sessions devoted to multiple schedule training and other parts of the experiment. During multiple schedule training periods, the observing key was transilluminated with a blue light and responses were recorded but had no scheduled consequences. Sessions terminated after 30 reinforcements and were conducted once per day six or seven days per week.

Table 1

Sequence of conditions for both experiments with the total number of sessions devoted to each condition shown in parentheses.

Experiment I				*Experiment II*	
P11	*P28*	*Y72*		*P11*	*P28*
M(8)	B(8)	B(10)		M(8)	M(8)
B(10)	T(18)	T(10)		B(8)	B(8)
E(20)	M(10)	B(52)		G(10)	R(16)
B(4)	B(44)	E(34)		M(8)	B(13)
M(7)	E(56)	M(8)		B(13)	G(20)
B(14)	M(8)	B(44)		R(9)	
E(42)	B(54)				
B(42)					
T(22)					
M(9)					
B(14)					

M = *mult* (10-sec 2-sec).

B = *mix* (10-sec 2-sec) + R_o contingency, S_o on for the duration of the component.

T = *mix* (10-sec 2-sec) + R_o contingency, S_o on for 10 sec.

E = *mix* (6-sec 6-sec) + R_o contingency, S_o on for the duration of the component.

R = *mix* (10-sec 2-sec) R_o contingency, S_o on for the duration of the component, R10 stimulus only.

G = *mix* (10-sec 2-sec) + R_o contingency, S_o on for the duration of the component, G2 stimulus only.

R_o = observing responses

Baseline (B) observing behavior. In this condition, both keys in the chamber were transilluminated with a white light and the schedule on the left key or food key was a *mix* (10-sec 2-sec). Here, one peck on the right key or observing key transilluminated the food key with a red light if the schedule was to terminate with 10-sec access to grain or a green light if the schedule was to terminate with 2-sec access to grain. In each case, the stimulus that followed an observing response (S_o) remained on for the duration of the component; following reinforcement, the color of the food key reverted to white and another observing response was possible. A peck to the observing key thus converted the schedule on the food key from a mixed to a multiple schedule. A changeover delay (COD) prevented a food-producing response from following an observing response by less than 10 sec. This lessened the chance that pecking the observing key would be superstitiously chained to obtaining food. If the birds did not peck the observing key, responding on the food key still produced food on a *mix* (10-sec 2-sec) schedule of reinforcement.

Duration of S_0 equalled 10 (T) sec. In the baseline observing behavior condition, the S_0 remained on for the duration of the component. In the present condition, the duration of the S_0 was changed to 10 sec. Following offset of the S_0, a peck on the observing key would be followed by another 10-sec presentation of the stimulus signalling the scheduled component. With the exception of this manipulation, all other aspects of the experiment remained the same as in the baseline condition.

Equal (E) reinforcement magnitudes. The duration of reinforcement was equalized for both components of the compound schedule. As a result, both components (R6 or G6) were FI 1-min with reinforcement consisting of 6-sec access to grain. An observing response produced a red stimulus or a green stimulus; in either case, the S_0 remained on for the duration of that particular component. All other aspects of this condition remained the same as in the baseline condition.

Exceptions in the case of P11. At several points in the course of the experiment P11 required special handling. Following the first *E* condition, the duration of reinforcement was changed to 10 sec signalled by red and 2 sec signalled by green. Observing behavior increased for two days and then declined. Next, P11 was given seven days of *mult* (10-sec 2-sec) schedule training (see Table 1). Subsequently, the opportunity to observe was reintroduced; both keys were transilluminated white and the conditions were the same as in the *B* condition. Observing behavior decreased after showing an initial increase. P11 was then shaped to peck the observing key with primary reinforcement (access to grain). After 15 reinforced pecks to the observing key, P11 was again exposed to the schedule where the only consequence of an observing response was a stimulus (red) signalling 10-sec access to grain or a stimulus (green) signalling 2-sec access to grain, depending on the component programmed.

Following this, the *E* condition was reintroduced for 32 sessions; the color of the observing key was then changed to blue, and an additional 10 sessions were conducted.

RESULTS AND DISCUSSION

Figure 1 shows a typical cumulative record for Y72, during a condition when observing behavior was maintained, and is representative of the behavior for the three subjects. This record shows that observing responses normally occurred after reinforcement during the post-reinforcement pause and before responding on the food key had begun. After the birds began responding on the food key, pecks on the observing key were highly unlikely.

The probability of an observing response is defined as the total number of components in which an observing-key peck occurred divided by the total number of components per session. For example, if the observing key was pecked in 18 of the 30 components, the probability would be 0.60.

Figure 2 shows the probability of an observing response during the various parts of the experiment for each bird. In all cases, each point is a two-day average.

When the duration of the S_0 was changed from the duration of the component to 10 sec, observing response probability declined substantially. This decrement was particularly marked in the case of Y72 and P11. When the S_0 once again remained on for the duration of the component, following multiple schedule training in the case of P28 and P11, observing response probability increased beyond the

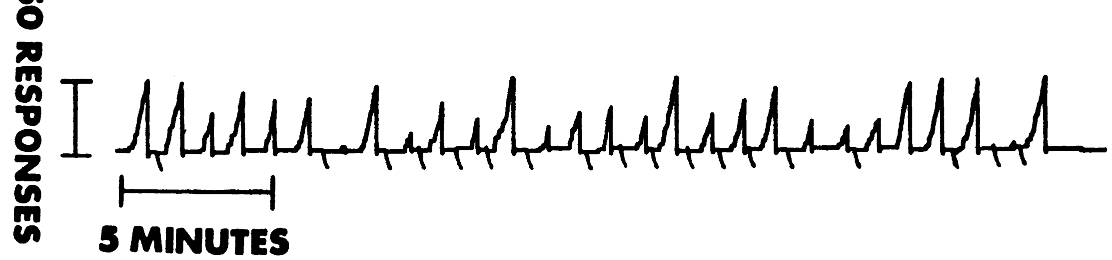

Fig. 1. A sample cumulative record for Y72 when observing behavior was maintained in a differential reinforcement magnitude condition of Experiment I. Slash marks represent observing-key responses. The cumulative recorder reset at reinforcement.

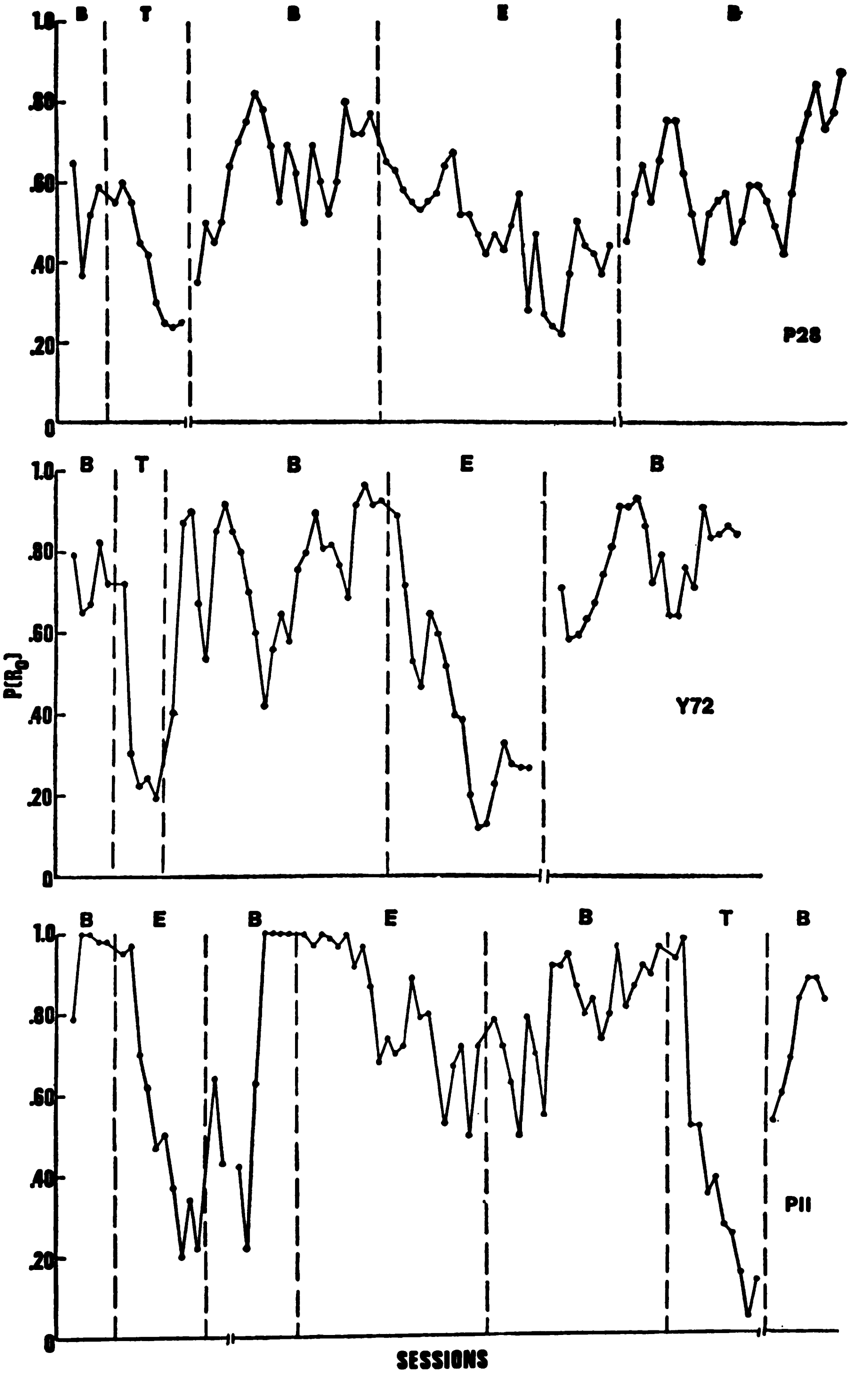

Fig. 2. Each point shows the probability of an observing response, $P(R_o)$ averaged over two sessions for each bird during the various parts of Experiment I. During baseline (B) conditions, the stimuli that followed observing responses signalled differential reinforcement magnitudes and remained on for the duration of the components. In the other conditions, the stimuli that followed observing responses remained on for 10 sec (T) and signalled differential reinforcement magnitudes, or remained on for the duration of the components, but signalled equal (E) reinforcement magnitudes. Breaks in the abscissa represent periods of interpolated multiple schedule training.

former baseline condition for P28, and closely approximated the preceding baseline for P11. Similarly, changing the duration of the S_0 from 10 sec to the duration of the component, without interpolated multiple schedule training, resulted in a sharply increased probability of an observing response for Y72.

After equalization of reinforcement magnitude, observing response probability decreased quite quickly for Y72 and P11, and less so for P28. The last eight days of this condition show a substantial decrease in observing response probability from the preceding condition where reinforcement magnitude was differential.

After multiple schedule training, Y72 quickly reacquired observing behavior while for P28 reacquisition was less rapid. Both P28 and Y72 reached relatively high levels of observing behavior that closely approximated the levels achieved in the preceding differential reinforcement magnitude condition.

Observing behavior for P11, following the first equal reinforcement magnitude condition, showed a brief increase and then declined. After seven sessions of multiple schedule training, the opportunity to observe was reintroduced; however, observing behavior failed to develop over the course of four sessions. At this point, 15 pecks on the observing key were reinforced with access to grain during the next two sessions. Subsequently, P11 observed in 100% of the components for the next eight sessions. The equal reinforcement magnitude condition was again introduced for this bird; observing response probability decreased over 32 sessions. The color of the observing key was then changed to blue for an additional 10 sessions. Observing response probability decreased further but did not reach the low level of the first equal reinforcement magnitude condition.

EXPERIMENT II:
EFFECTS OF REMOVAL OF THE STIMULUS SIGNALLING THE LARGER REINFORCEMENT MAGNITUDE

Kendall and Gibson (1965) reported an observing response experiment in which pecks on the observing key produced either a stimulus signalling fixed interval (FI) or a stimulus signalling fixed ratio (FR) depending on the component arranged. During this compound schedule the relative reinforcement rate in FR was greater than in FI. These investigators found that when the FR stimulus was the only occasional consequence of pecking the observing key, *i.e.,* when pecks on the observing key produced the FR stimulus when the FR component was scheduled but did not produce the FI stimulus when the FI component was scheduled, observing behavior was maintained. However, if the FI stimulus was the only occasional consequence of an observing-key response, observing behavior decreased substantially. Kendall and Gibson argued that observing responses were maintained by the superior effectiveness of the FR stimulus as a conditioned reinforcer. This contention is supported by evidence that the conditioned reinforcing strength of a stimulus is a function of the frequency or rate of primary reinforcement occurring in its presence, but is independent of the response rate or response pattern the stimulus signals (Herrnstein, 1964; Kelleher and Gollub, 1962; Killeen, 1968, 1971). Hence, the Kendall and Gibson study suggests that the occasional presentation of the stimulus signalling the higher rate of reinforcement is necessary for the maintenance of observing behavior. Accordingly, in one condition of the following experiment the stimulus signalling the larger reinforcement magnitude was the only occassional consequence of pecking the observing key, while in another condition, the stimulus signalling the smaller reinforcement magnitude was the only occasional consequence of pecking the observing key.

METHOD

Subjects

Pigeons P28 and P11 from the previous experiment were maintained at between 75 and 80% of their free-feeding weights.

Apparatus

Same as Experiment I.

Procedure

Multiple schedule training. The birds were given eight days of *mult* (10-sec 2-sec) schedule training; all conditions were the same as the multiple schedule training periods of Experiment I. Table 1 shows the sequence of experimental conditions and the total number of sessions devoted to each part of the experiment.

Baseline (*B*) *observing behavior.* Same as Experiment I.

R10 stimulus (*R*) *only.* In this condition, a peck on the observing key when the component would terminate with 10-sec access to grain produced the red stimulus for the duration of the component; however, when the component would terminate with 2-sec access to grain, pecking the observing key had no scheduled consequence, *i.e.,* the mixed schedule stimulus remained on the food key where formerly the key changed to green. All other aspects of this condition were the same as the B condition.

G2 stimulus (*G*) *only.* A peck on the observing key when the component would terminate with 2-sec access to grain produced the green stimulus for the duration of the component. If the component would terminate with 10-sec access to grain, pecking the observing key had no scheduled consequence, *i.e.,* the mixed schedule stimulus remained on the food key where formerly the key changed to red. All other aspects of this condition were the same as the B condition.

Results and Discussion

Figure 3 shows sample cumulative records of responding during periods when observing behavior was maintained with both stimuli available and when only the R10 stimulus was available. The records for the two pigeons, with one exception, are qualitatively similar and show typical FI behavior (Ferster and Skinner, 1957) with a post-reinforcement pause followed by accelerated responding to a high terminal rate. The only discernible difference between these records concerns the multiple pecks on the observing key that occasionally occurred when the initial observing-key peck had no consequence, that is, when 2-sec access to grain was scheduled. When this was the case, both birds would occasionally continue rapidly responding on the observing key, emitting 10 or more pecks, as reflected in the bottom record of Figure 3. As in the preceding experiment, observing responses were most likely during the post-reinforcement pause and before responding on the food key had begun. The cumulative records also reveal that the birds would occasionally pause after making an observing response before responding on

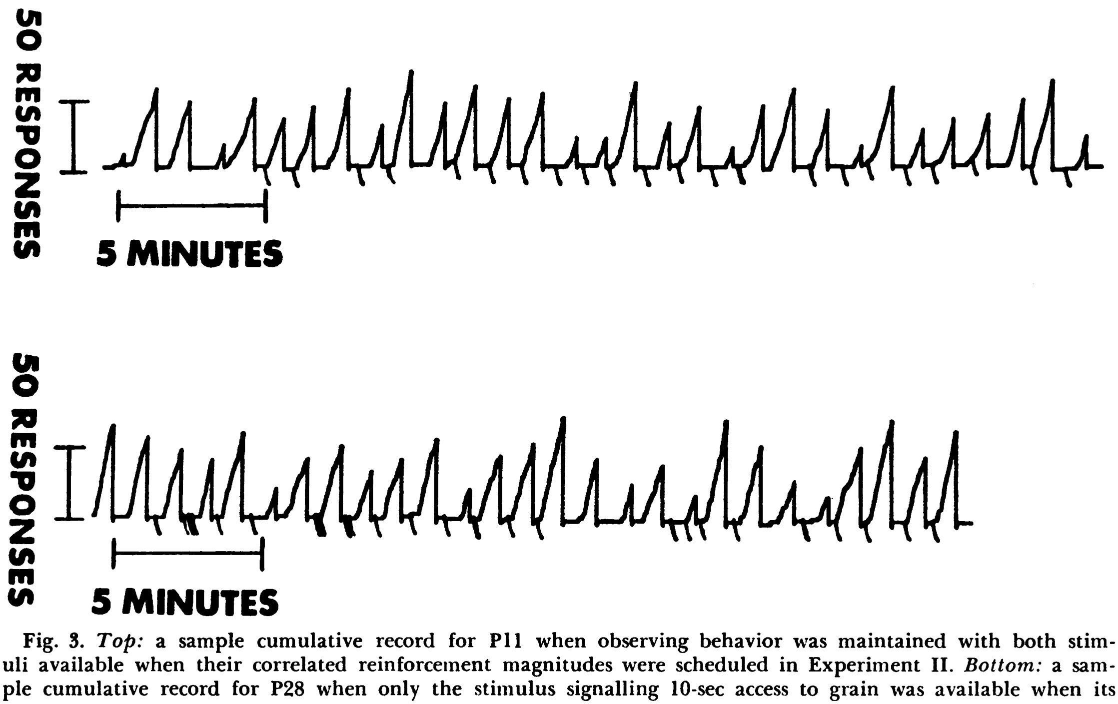

Fig. 3. *Top:* a sample cumulative record for P11 when observing behavior was maintained with both stimuli available when their correlated reinforcement magnitudes were scheduled in Experiment II. *Bottom:* a sample cumulative record for P28 when only the stimulus signalling 10-sec access to grain was available when its correlated reinforcement magnitude was scheduled in Experiment II. In both cases, slash marks represent observing-key responses. Multiple pecks on the observing key occasionally occurred when 2-sec access to grain was scheduled and observing-key pecks had no scheduled consequence. The cumulative recorder reset at reinforcement.

the food key. Whether or not this was systematically related to production of the G2 or R10 stimulus cannot be determined from the present data.

Figure 4 illustrates the probability of an observing response for each part of the experiment for the two subjects for each session.

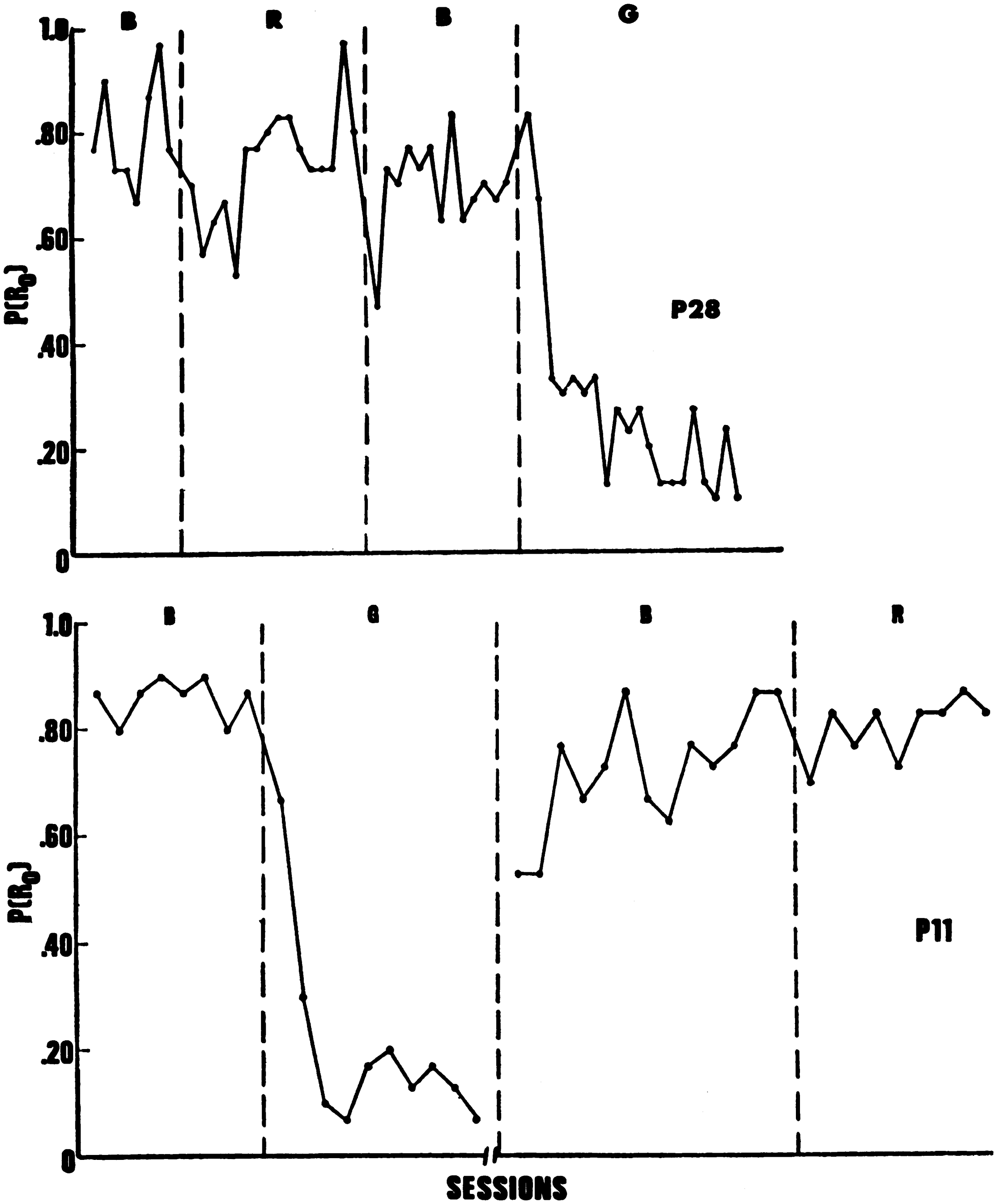

Fig. 4. Each point shows the probability of an observing response, $P(R_o)$, for each session during the various parts of Experiment II for the two subjects. During baseline (B) conditions, a peck on the observing key produced either the R10 stimulus or the G2 stimulus, depending on which reinforcement magnitude was scheduled. In the other two conditions, a peck on the observing key produced only the stimulus signalling 10-sec access to grain (R), or only the stimulus signalling 2-sec access to grain (G), but only if the correlated reinforcement magnitude was scheduled. The break in the abscissa for P11 represents a period of interpolated multiple schedule training.

When both stimuli were available, or when the R10 stimulus only was available, an observing response was a relatively high probability event for both subjects, although the daily variability was greater for P28 than for P11. On the other hand, when the only occasional consequence of pecking the observing key was the production of a stimulus signalling 2-sec access to grain, the probability of a peck on the observing key dropped substantially within three sessions for both birds. In the present experiment, the occasional presentation of the stimulus correlated with the larger reinforcement magnitude was necessary for the maintenance of observing behavior.

GENERAL DISCUSSION

The present experiments complement other observing response studies in which pigeons responded to produce stimuli signalling schedules that generated differential reinforcement rates (Branch, 1970; Hendry, 1969*b*; Kendall, 1965*a*, 1965*b*, 1968, 1969). For example, Branch (1970) showed pigeons would make observing responses during a *mix* VI 30-sec VI 120-sec and thereby convert the schedule to a multiple. The present experiments suggest that varying reinforcement magnitude is functionally similar to varying reinforcement rate.

During multiple schedule training, different stimuli were paired with two different reinforcement magnitudes, but when the opportunity to observe was introduced in Experiment I, the S_0 was either on for 10 sec or the duration of the component, depending on the condition. If the subject did not make an observing response, there was no obvious way to detect the reinforcement magnitude then scheduled, but by making an observing response, the subject obtained a stimulus signalling either a large or small reinforcement magnitude. With differential reinforcement magnitude, observing behavior was a relatively high probability event but only when the S_0 remained on for the duration of the component. In the equal reinforcement magnitude condition, the differential reinforcing strength of the two stimuli gradually decreased as all of the stimuli came to signal identical magnitudes. In other words, due to the constant reinforcement magnitude in this condition, the three stimuli, *i.e.*, white (mixed schedule), red and green (multiple schedule) came to signal identical consequences. In this condition, observing-key responses were not differentially reinforced and consequently declined. It seems that in certain situations, stimuli that signal differential consequences are reinforcing and function as conditioned reinforcers (Kelleher and Gollub, 1962) that maintain observing behavior. The nature of the differences that must exist in order for observing behavior to develop and be maintained in a discrimination paradigm awaits explication. In Experiment I, when the stimuli remained on for the duration of the components and signalled differential reinforcement magnitudes, conditions were favorable for the development and maintenance of observing behavior.

It seems reasonable that the number of sessions for the equal reinforcement magnitude condition to show an effect reflects the development of control by reinforcement duration. In the presence of both the green and red stimuli, 4 sec hopper time was either added to or subtracted from the reinforcement duration for each component. This interpretation is supported by Elsmore (1971), who found that control of responding by stimulus durations of either 9 or 21 sec, as reflected in differences in response rates, developed gradually over 40 sessions.

In a recent study investigating the effects of reinforcement magnitude on stimulus control, Mariner and Thomas (1969) showed that when the duration of the feeding cycle was cued by different intensities of the food-hopper light, stimulus control was enhanced. This cueing procedure was also found to be necessary to produce peak shift consistently. In the present study, stimulus control, as evidenced by observing responses, developed without distinctive signals during the feeding cycle. The fact that performance was facilitated in the Mariner and Thomas (1969) study suggests that acquisition and extinction of observing behavior in the present experiments might have been facilitated if distinctive food-hopper lights had been correlated with the multiple schedule stimuli.

In cases where reinforcement magnitudes were equal but the contingencies were differential (see Kendall, 1965*b*, 1969) the presentation of brief stimuli signalling the contingencies (*i.e.*, temporal and behavioral relationships), but not contiguous with the presentation of food, maintained observing behavior. Yet, Experiment I demonstrated that stimuli that remained on for the duration of invariant FI 1-min schedules, and were thus contiguous with differential reinforcement magnitudes, were necessary for the maintenance of observing behavior. It may be that in order to maintain observing behavior, the stimulus signalling the most highly valued possible consequence (consider Experiment II) must precede that consequence closely in time in order to function as a conditioned reinforcer. For example, when the contingencies were differential, the maintaining stimulus preceded closely in time the major portion of the shorter interreinforcement interval in a multiple schedule (Kendall and Gibson, 1965), while in the present case, the maintaining stimulus preceded closely in time (and accompanied) the larger reinforcement magnitude. Hence, while taking into consideration the results of Experiment II, it seems reasonable that in Experiment I, a brief stimulus did not maintain observing behavior at a relatively high probability because the stimulus signalled an invariant FI 1-min contingency and was substantially removed in time from the larger reinforcement magnitude.

Experiment II showed that the occasional presentation of the stimulus signalling the larger reinforcement magnitude was necessary for the maintenance of observing behavior. When the only occasional consequence of an observing response was the acquisition of a stimulus signalling the smaller reinforcement magnitude, observing behavior decreased markedly. In this condition the pigeons chose to behave in the presence of the mixed stimulus for a substantial number of components per session, *i.e.,* the stimulus that signalled, on the average, an intermediate reinforcement magnitude, 6 sec access to grain. This experiment, then, complements the study by Kendall and Gibson (1965), which showed that the occasional presentation of the stimulus signalling the higher reinforcement rate was necessary for the maintenance of observing behavior.

An information theory of conditioned reinforcement (Hendry, 1969*a*) suggested that the occasional presentation of either stimulus alone should maintain observing behavior, because according to the quantitative theory of information (Garner, 1962) *either* stimulus alone gives all the information, *i.e.,* 1 bit, in a situation where the two possibilities have equal probabilities of occurrence. That is to say, if only one stimulus is an occasional consequence of pecking the observing key, and that stimulus is reliably associated with one of the two equally probable components, when that stimulus does not follow a peck on the observing key the other component must necessarily be in effect. According to information theory, this relationship must occur regardless of the stimulus that is an occasional consequence of pecking the observing key. However, in Experiment II, the occasional presentation of the stimulus signalling the larger reinforcement magnitude maintained observing behavior; while observing behavior decreased markedly when the only occasional consequence of pecking the observing key was the presentation of the stimulus signalling the smaller reinforcement magnitude. These data suggest that observing behavior during a two-component compound schedule is reinforced by the stimulus signalling the most highly valued possible consequence, where value is a function of the context. For example, the stimulus that reinforces observing behavior may be the stimulus signalling: (1) the absence of a schedule of punishment (Dinsmoor, Flint, Smith, and Viemeister, 1969); (2) the presence of a reinforcement schedule (Dinsmoor, Brown, and Lawrence, 1972); (3) the contingency generating the shorter interreinforcement interval (Kendall and Gibson, 1965); or (4), in the present case, the larger reinforcement magnitude.

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