Reinforcement: A test of Premack's differential probability rules

by

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ABSTRACT

According to Premack's (1959) basic assumptions, reinforcement will occur only in a contingency relationship where the independent probability of the contingent response is higher than the independent probability of the instrumental response. To test this assumption, free-operant baselevels of running alone (phase I), drinking alone (phase II), and running and drinking simultaneously (phase III) were established for six rats. Independent response probabilities were calculated from these data. A run to drink contingency was then instituted which required each subject to increase the probability of the instrumental response above baselevel in order to maintain the contingent response at baselevel. In all cases reinforcement was observed <u>regardless</u> of the prior independent probabilities of the two responses.

Introduction

Instrumental conditioning can be viewed as a procedure which establishes a contingency relationship between a response and a reinforcer. When that contingency produces an increase in the probability of the instrumental response, psychologists have generally assumed that a reinforcement process has operated. The nature of that reinforcement process and the necessary and sufficient conditions for its operation are differentiated in the various reinforcement theories.

Premack (1959; 1965; 1969) challenged the views of traditional behaviourists (Hull, 1943; Skinner, 1938) towards reinforcement when he suggested that reinforcement is not an absolute property of certain stimuli, but will occur in _any_ contingency relationship where the independent probability of the contingent response is higher than the independent probability of the instrumental response. Specifically, those postulates which differentiate Premack's view of reinforcement from the traditional views can be summarized as follows: (a) Physically different responses can be compared directly through the use of duration based probability measures. (b) In any pair of responses a more probable response will reinforce a less probable one. (c) The reinforcement value of a response is determined by the independent response probabilities regardless of the parameters involved in producing the response. (d)

Reinforcement properties of a response are relative to all other available responses. (The most probable response in a set of responses will reinforce all other responses in that set while the least probable response will reinforce none.) (e) If the relative probabilities can be reversed for a pair of responses, then the reinforcement relationship for that pair of responses is also reversible.

A substantial amount of behavioural data has accumulated in support of Premack's theoretical assumptions. The basic notion that the more probable of two responses will reinforce the less probable response has been substantiated in a variety of situations with a variety of responses and species.

In rats, barpressing has been reinforced by drinking (Premack, 1961), running by drinking (Jacobsen & Premack, 1970; Premack, 1962), drinking by running (Premack, 1962; Schaeffer, 1965), barpressing by running (Hundt & Premack, 1963), and licking by intra-cranial self-stimulation (ICSS) (Holstein & Hundt, 1965).

In Cebus monkeys, the opportunity to operate one of four manipulanda (a vertical lever, a plunger, a door, or a horizontal lever) in order to obtain the chance to operate a second manipulandum of the same set with a higher independent response probability was found to be reinforcing. If however, the second manipulandum was associated with a lower independent response probability, reinforcement did not occur (Premack, 1963).

With humans, children who made more baselevel responses of playing a pinball machine than eating candy increased their number of eating responses when pinball playing was contingent upon eating candy; and likewise, children who originally ate more candies increased their manipulations of the pinball machine when eating was contingent upon manipulating (Premack, 1959). Premack's assumptions have also been supported with human Ss when instrumental contingencies were arranged between two physically identical responses (Schaeffer, Hanna, & Russo, 1966; Wasik, 1968). College students were presented with two identical telegraph keys under differential schedules of reinforcement (accumulation of points was the reinforcer). On one key the S received a point for every key press (CRF), on the second key, every fifth press was worth one point (FR-5). In the contingency session the rate of pressing the FR key increased when pressing the CRf key was contingent upon responding on the FR key.

The reversibility of the reinforcement relationship has also been demonstrated by Premack (1962). Rats were initially permitted free access to food and an activity wheel, but allowed access to water for only one hour per day. This procedure established drinking as the more probable response and run to drink (R ⊃ D) as the instrumental contingency. By changing the deprivation conditions -- free access to food and water, but limited access to the activity wheel for one hour per day -- Premack established running as the more probable response and drink to run (D ⊃ R) as the instrumental contingency. For both conditions reinforcement was demonstrated by an increase in the response probability of the instrumental response.

In a subsequent elaboration of the theory (Premack, 1969), the necessary and sufficient conditions for punishment were discussed in terms of relative response probabilities. When the independent probability of the contingent response is lower than the independent probability of the instrumental response (the exact opposite of the reinforcement contingency) Premack suggested that the instrumental response will be suppressed, the behavioural consequence of an assumed punishment process.

To test this punishment assumption, rats were forced to run in a motorized activity wheel contingent upon licking a drinking tube. The probability of the drinking response increased if running (contingent response) was the more probable response (L ⊃ H); whereas drinking was suppressed if running (contingent response) was the less probable response (H ⊃ L) (Terhune & Premack, 1970; 1971; Weisman & Premack, 1966 in Terhune & Premack, 1970). These data support Premack's assumptions concerning a symmetrical reinforcement/punishment mechanism based on independent response probabilities.

A close examination of the data in support of Premack's basic reinforcement and punishment assumptions (Premack, 1965; 1969) reveals at least two major deficiencies: (a) with respect to the reinforcement assumption, every procedure in which it has been demonstrated that a more probable response would reinforce a less probable response the subject was required to increase the probability of the instrumental response in order to maintain the contingent response at the independently measured free performance level (Premack, 1961; 1962; 1963); (b) with respect to the punishment assumption, every procedure in which it has been demonstrated that a less probable contingent response would punish a more probable instrumental response, in order to hold the instrumental response at its free operant level, the subject was required to increase the probability of the contingent response above the independently measured free performance level (Terhune & Premack, 1970; 1971).

Hence, the possibility still remains, in view of the above two problems, that: (a) a less probable response can be demonstrated to reinforce a more probable response if the contingency requirements are arranged such that the subject _must increase_ the probability of the _instrumental response_ in order to maintain the free-operant level of the contingent response, and (b) a more probable response can be demonstrated to punish a less probable response if the contingency requirements are arranged such that the subject _must increase_ the probability of the _contingent response_ above its independently measured free-operant level if the instrumental response is to be maintained at free performance level.

Any demonstration of a less probable contingent response reinforcing a more probable instrumental response would seriously question the validity of _both_ the reinforcement and punishment assumptions made by Premack. The present experiment employed rats in a situation which permitted two responses, running and drinking, to be measured. Once the independent response probability of each of these responses was established, run to drink contingencies were arranged in which each rat increased the more probable instrumental response above the free-operant level in order to maintain the contingent response at its free-operant level.

Method

Subjects

Six experimentally naive adult male albino rats (COBS) obtained from Charles River Ltd., St. Constant, Quebec were used as subjects. Each rat was housed individually. For the duration of the experiment, the animals were maintained on ad lib food, 23 hour water deprivation, and 24 hour light cycle.

Apparatus

The apparatus used consisted of a single modified Wahmann activity wheel housed in a ventilated, sound attenuating chamber located in the room adjacent to the room housing standard Grason Stadler relay control components.

The normal hardware cloth floor of the wheel was replaced by 84 three millimeter brass bars spaced 12 millimeters apart around the circumference of the wheel. A motor and cam mechanism permitted a drinking tube to be retracted or inserted. A Grason Stadler model E 4690A-1 drinkometer recorded licking. A solenoid operated brake was available to stop the activity wheel and hold it in a fixed position.

Procedure

The animals were adapted to the laboratory for three weeks prior to being placed on a 23 hour water deprivation schedule for ten days. After the initial adaptation period, experimental sessions 60 minutes in length were conducted at the same time seven days per week. Following each session the animals were returned to their home cages. In phase I the animals were given access to a drinking tube for one hour immediately following the experimental session. In all other phases water was only available during the experimental session. The experimental procedure was divided into four phases:

Phase I: Each rat was placed in the apparatus with the brake released and the drinking tube retracted for 15 sessions of free access to the running wheel. The running response was recorded in two ways: (a) frequency -- the number of 90° turns that the animal made in the wheel and (b) duration -- the cumulative number of two second (2") intervals in which the animal engaged in the state of running. The duration measure was obtained with appropriate electronic circuitry which divided the entire experimental session into 2" intervals, and scanned each interval to determine if a running response had been emitted during those two seconds.

Phase II: During phase II the running wheel was mechanically locked so that no running could occur. The drinking tube was inserted and baseline level of free-operant drinking was established. The drinking response was also monitored in 2 ways: (a) frequency of drinking (with an instance of drinking being defined as one lick on the drinking tube) was recorded as the number of licks emitted per session and (b) duration of drinking was recorded as the number of 2" intervals in which the animal emitted at least one lick. Phase II continued for 15 sessions.

Phase III: Phase III permitted the measurement of a two-response baseline by allowing the animal free access to both running wheel (brake released) and drinking tube (tube inserted). Running and drinking responses were recorded in the same manner as they were during the establishment of each individual baseline. These data were converted to response probabilities by dividing the number of 2" intervals available in each experimental session (cf. Premack, 1965).

Phase IV: In phase IV, a run to drink contingency was arranged for all animals. To commence each session the wheel was available for free access running (brake released) and the drinking tube was retracted. A fixed ratio schedule was selected for the individual animals in which a fixed number of quarter revolutions in the wheel (instrumental response) produced the drinking tube for a set number of licks (contingent response), after which the tube was again retracted. Instrumental and contingent requirments for the six subjects are found in Table 1. The instrumental requirement was arranged such that the animal had to increase his running base rate (as measured in phase III)

TABLE 1

Instrumental and Contingent Requirements for All Subjects During Contingency Training

Subject	Instrumental (run) No. of 90° revolutions	Contingent (drink) No. of licks	Response Probabilities in Contingency Determined by base level responding
1	5	30*	L > H
2	8	35	* *
3	10	20	H > L
4	8	35	* *
5	10	30	H > L
6	9	30	H > L

* Originally the contingent response was set at 50 licks; this was adjusted after 3 days because the animal was not forced to increase his instrumental response level in order to maintain the contingent response at base level.

** These animals showed no consistent difference in probability levels for the two responses.

by approximately 50% in order to maintain the contingent response at base level. It was fortuitous that all possible combinations of response probabilities are represented by the establishment of a run to drink contingency. Baselevel responding in phase III shows that run was more probable than drink for Ss 3, 5, and 6 (H ⊃ L), drink was more probable than run for S1 (L ⊃ H), and no consistent response preference was observed for Ss 2 and 4.

The running wheel remained at free access through the entire session, thus running was possible for both states of the drinking tube, inserted or retracted. Responding during contingency sessions was recorded in the same manner as described for phase III. Phase IV lasted 15 sessions.

Results

The data for each subject are presented separately in Figures 1-6. As seen in phases I, II, and III of the experiment, the deprivation parameters produced three subjects in which run was more probable than drink (Ss 3, 5, and 6); one subject in which drink was more probable than run (S1); and two subjects without any consistent preference (Ss 2 and 4).

Reinforcement, when defined as an increase in the instrumental response, was observed in all subjects during the contingency sessions in phase IV of the experiment. This increase occurred regardless of the independent response probabilities of the two responses (running and drinking) as measured prior to the arrangement of the instrumental contingency (run in order to drink). In all six subjects the increase in instrumental responding exceeded the free-operant baselines as measured in either the single response session (phase I) or two-response sessions (phase III).

In addition to the increase in the total amount of instrumental responding, the arrangement of the contingency produced a change in the pattern of responding. Representative response patterns from a typical subject during free-operant and contingency sessions are presented in Figure 7. The irregular sequences of running and drinking observed during free-operant sessions are

Fig. 1. Probability of running (phase I), drinking (phase II), and running and drinking (phases III and IV) for S1.

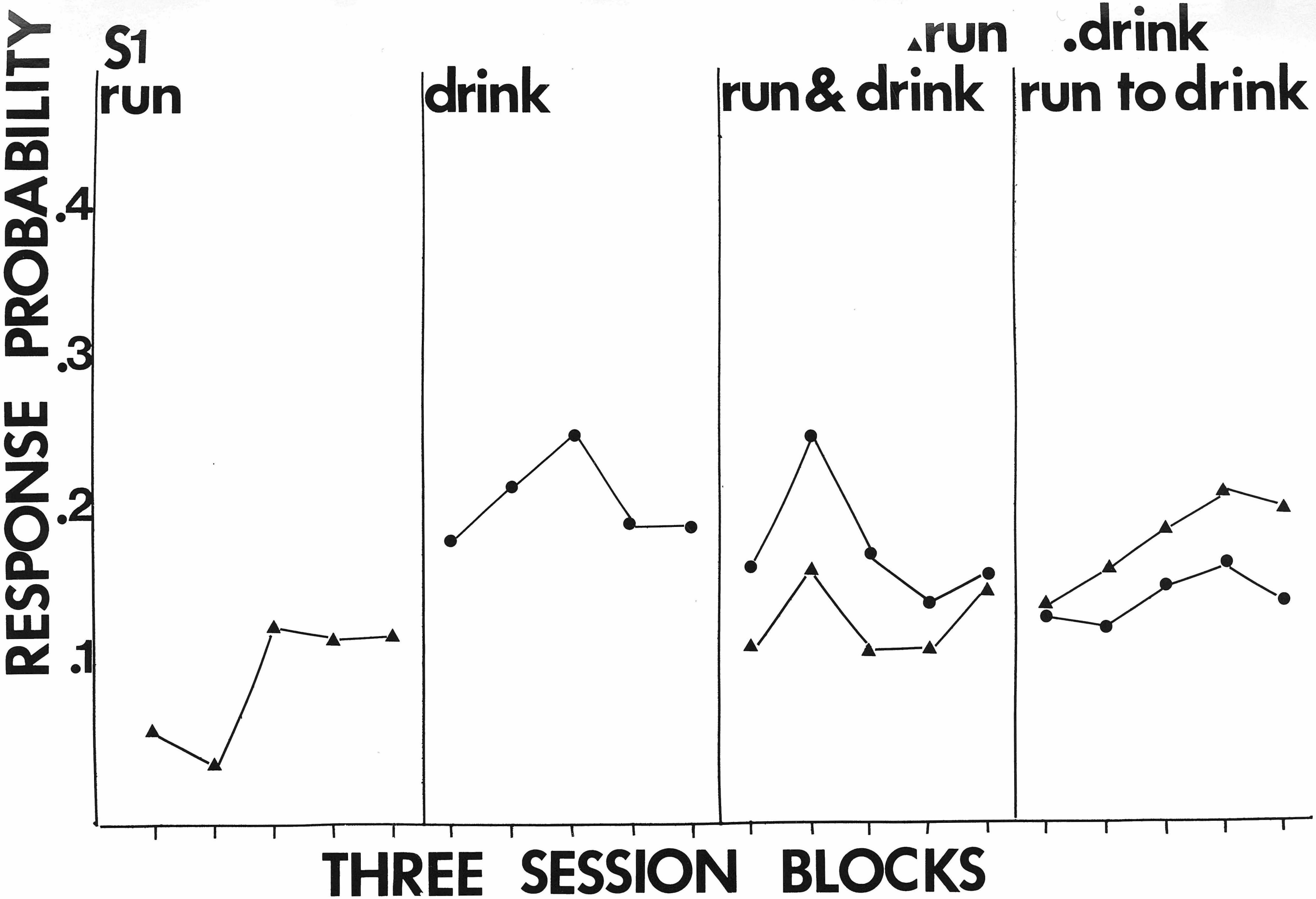
S1
run
drink
▲run
run & drink
●drink
run to drink
RESPONSE PROBABILITY
.4
.3
.2
.1
THREE SESSION BLOCKS

Fig. 2. Probability of running (phase I), drinking (phase II), and running and drinking (phases III and IV) for _S_2.

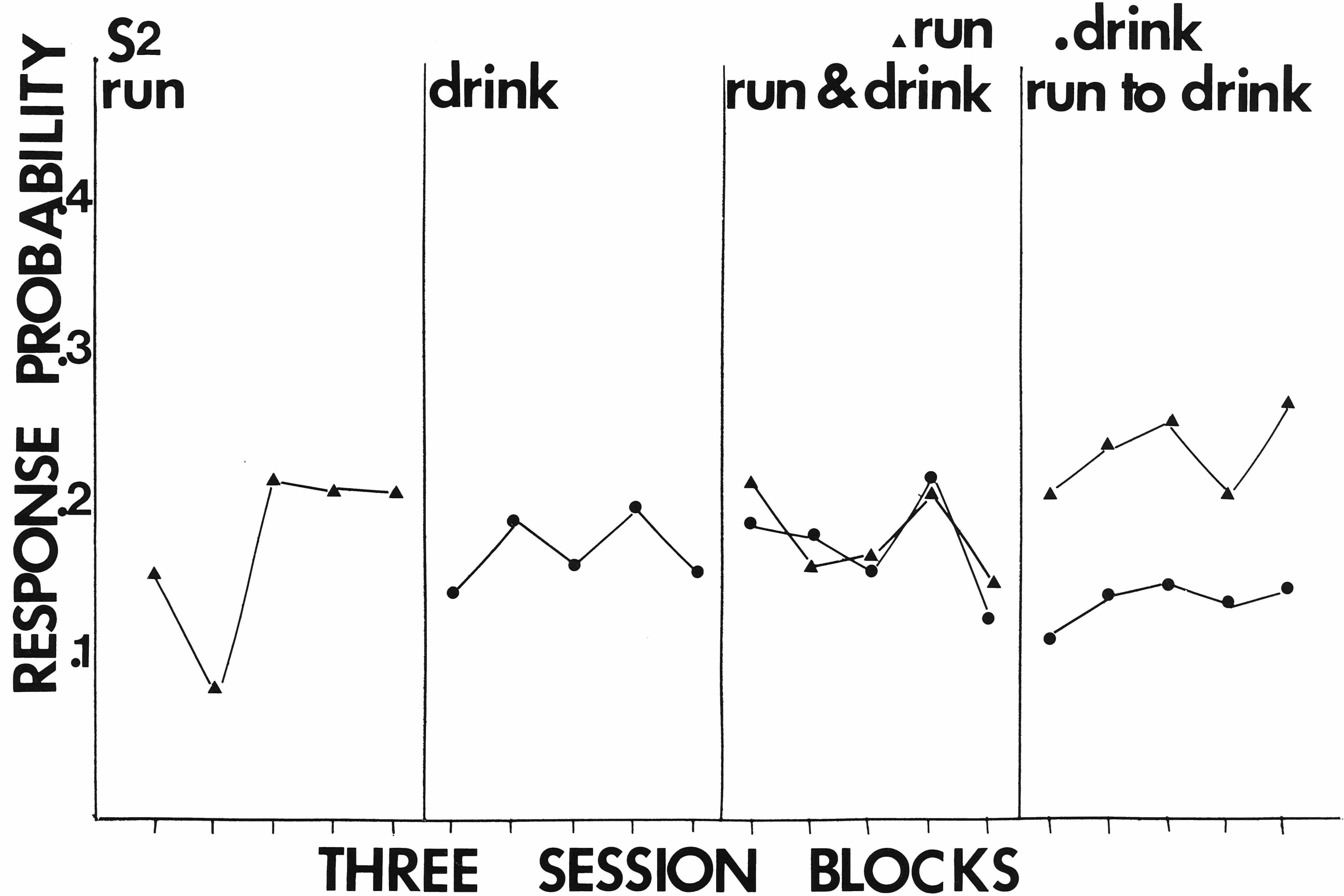
S2
run
drink
▲run
run & drink
•drink
run to drink
RESPONSE PROBABILITY
.1
.2
.3
.4
THREE SESSION BLOCKS

Fig 3. Probability of running (phase I), drinking (phase II), and running and drinking (phases III and IV) for S3.

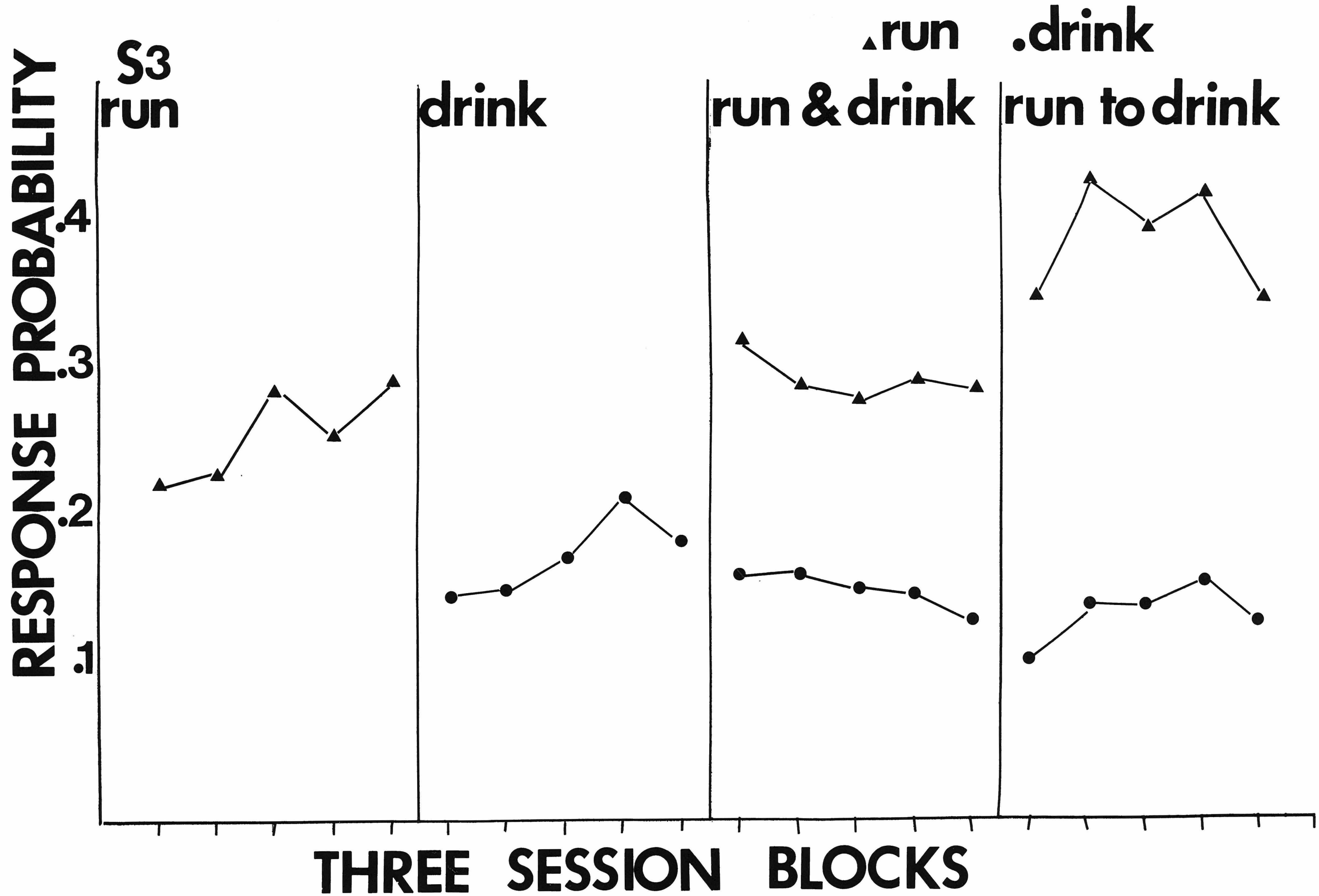
S3
run
drink
run & drink
run to drink
▲run
●drink
RESPONSE PROBABILITY
.1
.2
.3
.4
THREE SESSION BLOCKS

Fig.4. Probability of running (phase I), drinking (phase II), and running and drinking (phases III and IV) for S4.

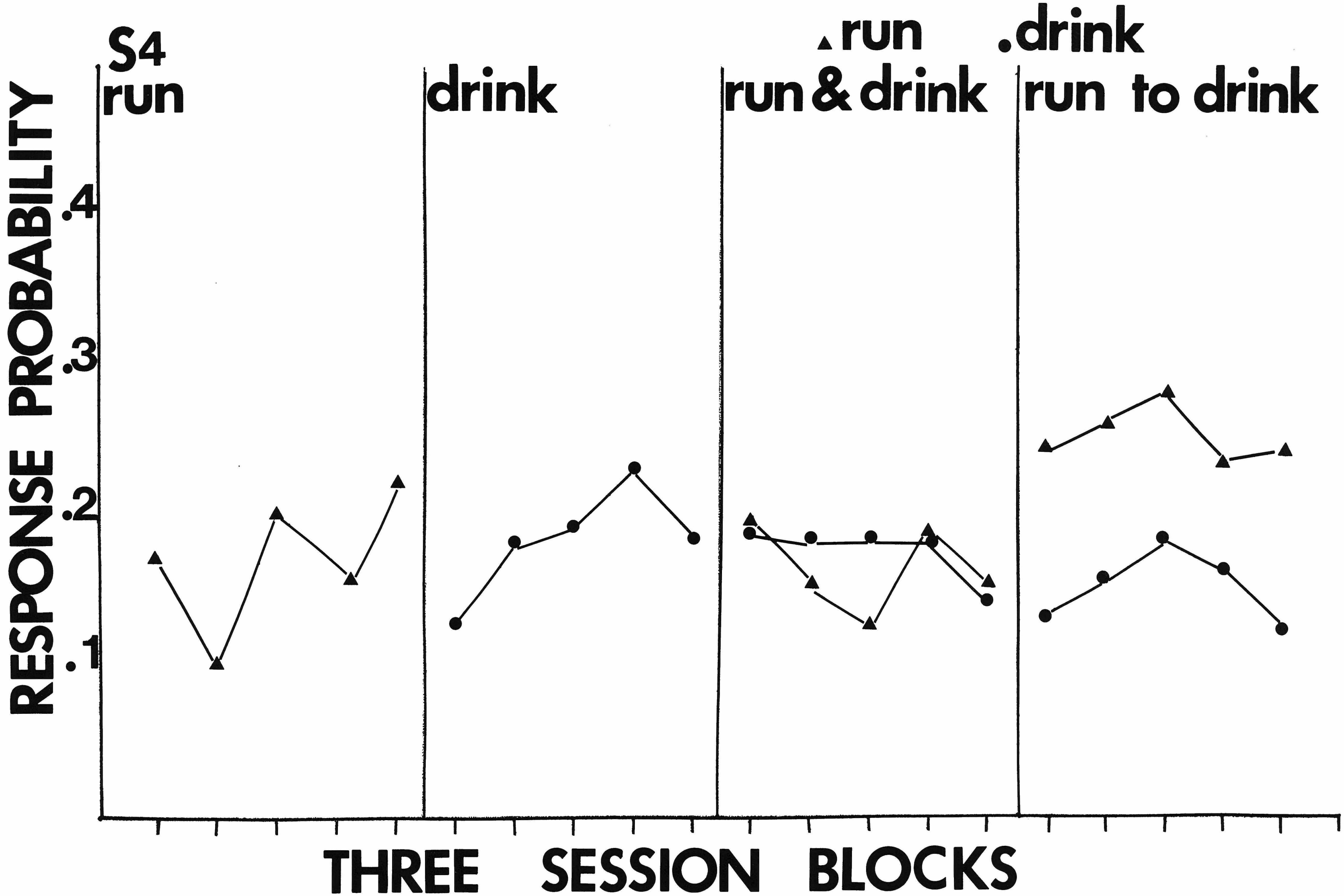
S4
run
drink
▲run
●drink
run & drink
run to drink
RESPONSE PROBABILITY
.4
.3
.2
.1
THREE SESSION BLOCKS

Fig. 5. Probability of running (phase I), drinking (phase II), and running and drinking (phases III and IV) for S5.

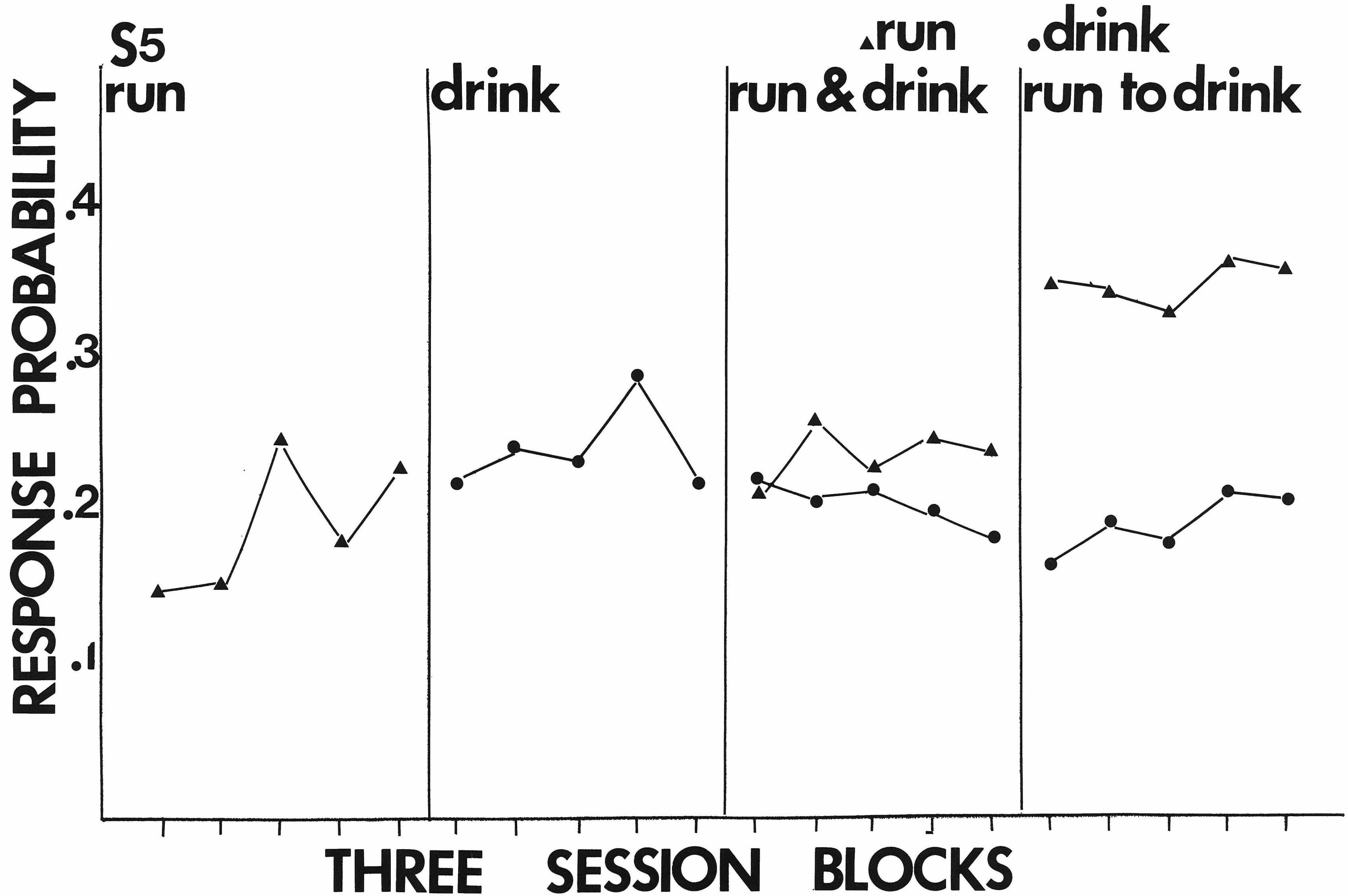
S5
run
drink
▲run
run & drink
●drink
run to drink
RESPONSE PROBABILITY
.1
.2
.3
.4
THREE SESSION BLOCKS

Fig. 6. Probability of running (phase I), drinking (phase II), and running and drinking (phases III and IV) for _S_6.

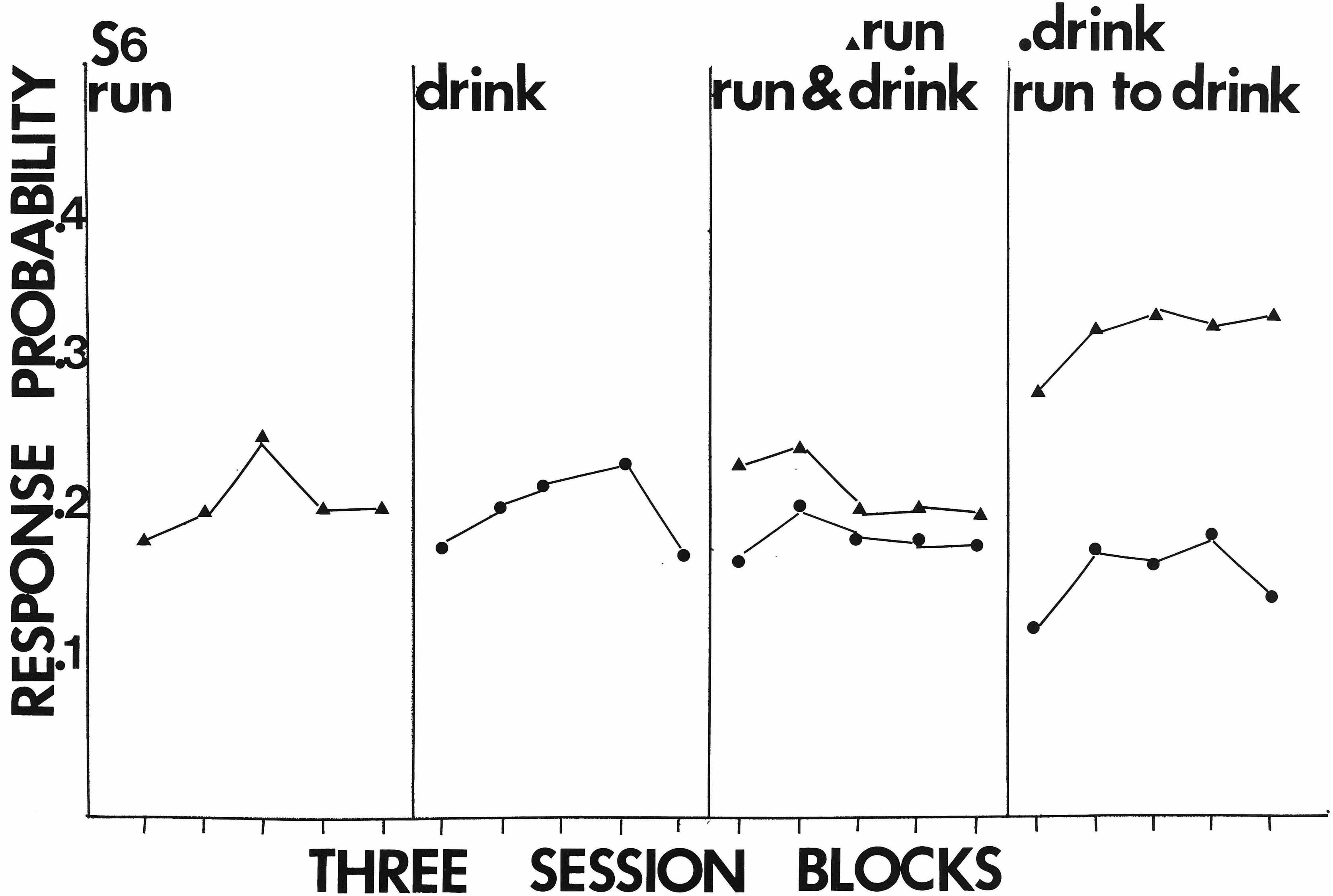
S6
run
drink
▲run
run & drink
●drink
run to drink
RESPONSE PROBABILITY
.4
.3
.2
.1
THREE SESSION BLOCKS

Fig. 7. Representative event records of the response patterning for a typical subject, S6, during phase I (establishment of a free-operant running baseline), phase II (establishment of a free-operant drinking baseline), phase III (establishment of a free-operant two-response baseline -- running and drinking) and phase IV (establishment of the run to drink contingency).


PHASE I
run
PHASE II
drink
PHASE III
drink
run
PHASE IV
drink
run

TABLE 2

Comparison of Response Probabilities: Phases III and IV

Subject	X Response Probability Phase III (Two-response baseline)		X Response Probability Phase IV (Contingency training)		% Change	
	R	D	R	D	R	D
1	.133	.181	.185	.145	+39%	-20%
2	.185	.181	.243	.141	+31%	-22%
3	.293	.155	.386	.140	+32%	-10%
4	.166	.177	.254	.152	+53%	-14%
5	.241	.208	.357	.195	+48%	- 6%
6	.218	.183	.322	.166	+48%	-10%

replaced during phase IV by the regular alternation of run bursts (instrumental response) and drink bursts (contingent response) required by the contingency.

Table 2 shows the average percent of change in the response probabilities during contingency sessions, based on the preceeding two - response baseline. An increase in instrumental responding was observed in all subjects. The increase ranged from 31% to 53%. In only one subject (S4, an animal with no response preference in free-operant sessions) did the percent of increase exceed that required by the pre-arranged contingency (a 50% increase) to maintain the contingent response at the free-operant level.

Note also (Table 2) that, for all subjects, the contingent response was only slightly suppressed by the introduction of the contingency. There was no significant correlation between the percent of increase in the instrumental response and the percent of suppression in the contingent response ($r = .48$; $df = 5$; $p > .05$).

Discussion

Premack (1969) considers reinforcement and punishment to be two symmetrical and opposite results of a contingency operation: *i.e.* if a more probable response is made contingent upon a less probable one, the result will be a facilitation of the instrumental response (reinforcement); if a less probable response is made contingent on a more probable one, the result will be suppression of the instrumental response (punishment). The case where there is no response preference presumably implies neither a reinforcement nor a punishment outcome.

The primary result of the present research was that reinforcement was observed independent of prior response probabilities. In all instances, whether the run to drink contingency represented a L $\supset$ H case (*S*1), a no preference case (*S*'s 2 and 4), or a H $\supset$ L case (*S*'s 3, 5, and 6), a substantial increase in the total amount of instrumental responding was observed. The demonstration of a less probable contingent response reinforcing a more probable instrumental response questions the validity of Premack's reinforcement *and* punishment assumptions.

In previous studies where Premack has demonstrated reinforcement in the L $\supset$ H contingency the subject has been required to increase the instrumental response in order to maintain the contingent response at free-operant level. Where the $H \supset L$ contingencies do not demonstrate reinforcement an increase in the instrumental response was not necessary to maintain contingent behaviour at its free-operant level. The contingencies in the present study were arranged such that each subject had to make an increase of approximately 50% in running in order to hold drinking at its base level, regardless of the prior independent response probabilities of both responses. Although only one subject increased the instrumental run response above 50% (*S*4, a no preference animal had an increase of 53%) all subjects approached the 50% increase arranged by the contingency (See Table 2). Thus these data suggest that *either response* in any pair of responses can be demonstrated to reinforce the other member of that pair if the contingency requirements are arranged so that the subject *must* increase the probability of the instrumental response in order to maintain the free-operant level of the contingent response.

Since the present data question Premack's differential probability rules for arranging either a reinforcement ($L \supset H$) or a punishment ($H \supset L$) contingency, a question remains as to the necessary and sufficient conditions for producing either a reinforcement or punishment outcome in any particular contingency relationship. One suggestion made by Premack (1965) and developed somewhat by Eisenberger, Karpman, and Trattner (1967) concerns the amount of contingent responding permitted during contingency testing. More specifically, Premack (1965, p. 172) suggested that the contingent response must be suppressed below the free-operant level by the contingency requirements if an increase in instrumental response (reinforcement) is to be observed. Eisenberger et al. examined this notion in several experiments using college students as subjects and lever pressing vs. wheel cranking as the instrumental and contingent responses. Their results indicated that reinforcement could be demonstrated only if the contingency arranged between the two responses produced a suppression of the contingent response probability below its free-operant level. Suppression of the contingent response was observed both when the instrumental response was less probable than the contingent response and more probable than the contingent response.

Although each contingency in the present experiment did manage to suppress the contingent response below the free-operant level (see Table 2), the data do not provide strong support for the suggestion that a suppression of contingent responding is the necessary condition for reinforcement to be observed. If the reinforcement process were dependent upon the suppression of the contingent response, one would expect a high positive correlation between the amount of increase in instrumental responding and the amount of decrease in the contingent response. The present data, admittedly drawn from a small sample, revealed no reliable correlation between these two measures. It would appear, therefore, that neither the differential probability rules suggested by Premack (1959) nor a suppression of the contingent responding is a sufficient basis upon which to base predictions about the outcome of any particular contingency arranged between two responses.

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