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Full Name of Author — Nom complet de l'auteur
Raymond Michael Wood

Date of Birth — Date de naissance
25 May 1953

Country of Birth — Lieu de naissance
U.S.A.

Permanent Address — Résidence fixe
4857 N. Santa Monica Blvd
Whitefish Bay, WI USA 53217

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Name of Supervisor — Nom du directeur de thèse
C. Donald Heth

Date
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Signature
Raymond Wood

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Access and performance: A response-based analysis of behavior

by

Raymond Michael Wood

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(signed) ______

PERMANENT ADDRESS:

4857 N. Santa Monica Blvd.

Whitefish Bay, WI 53217

DATED 19 Apr. 1 1983

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Access and performance: A response-based analysis of behavior submitted by Raymond Michael Wood in partial fulfilment of the requirements for the degree of Master of Science.

Supervisor

Date 19 April 1983

Abstract

Response based behavior analysis, as formulated by Premack (1959; 1965; 1971), attempted to explain response performance in relation to the context provided by the embedding response set (Rachlin & Burkhard, 1978) and the conditions which define response access or availability. Within this framework, reinforcement was seen as a class of access conditions that attempted performance modifications through the use of contingencies. The essence of a contingency was seen by Premack (1965) to be the response requirement of the instrumental response: the organism must increase its level of instrumental performance to obtain access to the contingent response. Imposition of a contingency, however, was insufficient for reinforcement. In addition to an imposed response requirement, Premack also stated that the contingent response must be of higher probability than the instrumental response and that the organism be kept from performing the contingent response at its operant level. In short, reinforcement necessarily disrupted the organism's operant, or free pattern of behavior by imposing response limits and a specified discontinuity of access to the contingent response. Subsequent research (Eisenberger, et al, 1967; Allison & Timberlake, 1974; Timberlake & Allison, 1974) challenged the necessity of having a higher probability contingent response by demonstrating that response suppression, or deprivation, was the only condition necessary to reinforcement given a contingency. The examination of reinforcement that resulted from this research generated other models and theories (Mazur, 1975; 1977; Rachlin & Burkhard, 1978) that addressed contingent and noncontingent performance changes. An issue

that had not been fully addressed (Timberlake, Note 1) was the control of noncontingent processes -- specifically discontinuity of access -- within contingent procedures. The present experiment attempted to control for discontinuiy using rats as subjects. Operant levels were established under conditions of single and paired continuous access to two saccharin solutions (0.2% and 0.4%); discontinuity effects were assessed outside of response requirements. During the Contingency period one group received 10 sec access to the 0.2% solution after performing 50 sec of 0.4% licking. The access and performance durations were consistent with the response deprivation model (Timberlake & Allison, 1974). A second group was yoked to the first and received the same temporal pattern of access independently of performance. A third group never received 0.2% access but instead received a 10 sec deprivation of 0.4% access after performing 50 sec of 0.4% licking. The Contingency period conditions failed to produce other than trivial performance modifications, making it awkward to evaluate the various models or the appropriateness of the control procedures. Obtained noncontingent performance modifications were seen as consistent with some positions (Premack, 1965; Mazur, 1977), inconsistent with others (Timberlake, Note 1; Rachlin & Burkhard, 1978), and outside the domain of another (Timberlake & Allison, 1974). Finally, it was suggested that subsequent research and model-building employ a more detailed analysis rather than one based on aggregate level measures.

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Introduction

The classic definition of reinforcement (Skinner, 1938) described it, in general, as "the presentation of a certain kind of stimulus in a temporal relation with either a stimulus or a response" (p. 62). This generality was subject to qualification, as generalities tend to be, because the effectiveness of even the most certain of that special kind of stimuli -- food -- was not always assured. It was widely known that sated organisms did not respond properly. Satiation was not seen as a stimulus category nor a classification applicable to the instrumental response and was, for these reasons, incorporated as a qualification, a boundary condition.

Premack (1959) recognized this qualification as a behavioral measure of stimulus effectiveness. Shock is effective only insofar as it elicits a response, food is effective only if it elicits a response like eating. On a more general level, reinforcement could be seen as the result of a particular relationship between a response and a stimulus that reliably elicits a set of behaviors or a single, terminal response (Staddon & Simmelhag, 1971). This description merely incorporates the exception as part of the rule. The non-traditional aspect of Premack's (1959) development was the emphasis on the response to the reinforcing stimulus as the crucial element; reinforcement was seen as response-response relationship:

> "Any response A will reinforce any other response B, if and only if the independent rate of A is greater than that of B" (p. 220).

One potential problem with this position was that of attempting to equate apples and oranges through the simplistic assumption that responses were directly comparable by rate. This problem of incommensurability between various response measures and topographically disparent responses was viewed as resolvable provided a "smallest possible unit (spu)" (p. 230) could be found for all responses such that one spu of a first response was comparable to one spu of any other response. The determination of spu's through analysis of unrestricted behavior was one of the stated goals of that paper.

It became an abandoned goal (Premack, 1965) as the required observation led to several complications and one elegant solution. The most serious complication, with rats at any rate, was that certain responses were characterized by "fixed" rates. This was most notable with licking (Stellar & Hill, 1952; Bolles, 1975) and apparently representative of eating and running (Premack & Schaeffer, 1963). When rate is so narrowly bound, rate differences are not representative of response differences. Equally important, increases in total amount of responding were not due to increases in response rate as expressed by number of responses per unit of time. Such increases represented an increase in the amount of time spent responding. Accordingly, Premack (1965) employed response duration as the dependent measure. All that remained was to insure comparability given differential conditions of response access.

In part, comparability was insured by translation of response durations to response probability measures. If R_a stands for the observed duration of response r_a and T_a symbolizes the time during which r_a was accessible, then the probability of r_a, $P(r_a)$, is target responses would not interact if both were simultaneously and freely accessible. This assumption, however, is inconsistent with the guiding conception that responses do react to the characteristics of the embedding set. Therefore the probabilities of the target responses must be assessed in a <u>paired</u> manner within an embedding set. The most accurate determination of response probabilities is achieved by paired access in the absence of any constraints on responding. With the issue of comparability resolved, it was possible to examine the process of reinforcement as quantified by response probabilities.

A sufficient examination of the reinforcement process requires the establishment of a contingency between two responses (Premack, 1965). These responses will evidence either equal probabilities, $P(r_a) = P(r_b)$, or unequal probabilities. We will ignore the contingent possibilities of the first outcome, for reasons that will soon become clear, and concentrate on the second outcome assuming $(Pr_a) > P(r_b)$. One possible contingency between these responses would set a response requirement on r_a such that R_a must be performed to produce the stimuli governing r_b. The second possible contingency would reverse the roles of the responses. Premack (1962; 1963a, 1963b; 1965) found that instrumental responding increased only when the higher probability response was the contingent response; that is, "of two responses, the more probable response will reinforce the less probable one" (p. 132); this statement formed the basis of what became known as the probability differential, or Premack principle.

The determination that a probability differential between two responses was necessary to reinforcement still left unanswered questions about the form of the relationship that must exist between those responses for increased instrumental performance to be obtained. Again the search began with the traditional assertion (Skinner, 1938), expanded in the study of superstitious conditioning (Skinner, 1948), that temporal relativity, or contiguity, was the sufficient form of relationship. Premack (1965) viewed temporal contiguity as the weakest possible relationship and the contingency as the strongest; strongest in the sense that certain other conditions were operative in contingency that were not present in temporal contiguity. These "major surplus conditions" were:

1) a response requirement, that the contingent response occurs only if the instrumental response is performed to some criteria;

2) a circumscription of the "organism's characteristic way of responding to" the instrumental and contingent responses by imposing limits on the response episodes (how long, how often); and

3) "a reduction in the total amount or duration" of contingent responding.

Skinner (1948) in his investigation of superstitious, or non-contingent conditioning, had shown that the response requirement was not necessary and concluded on the basis of this research that temporal contiguity was the necessary and sufficient form of relationship. Premack (1965) argued that "although Skinner's procedure is weaker than contingency, it is not yet a pure case of temporal contiguity" (p. 167). Both response circumscription and reduction were postulated to exist because the "reinforcer" was not freely available but delivered in limited quantity according to a specific schedule. The brunt of Premack's argument being that temporal contiguity, in its pure form, exists only when responses are freely accessible.

Under conditions of free access it was observed that drinking had a higher probability than running in an activity wheel -- satisfying the probability differential principle. The instances of run followed by drink within 2 sec. of run termination were counted and the effects of these instances charted over the series of 15 min. sessions. Despite the number of times such response sequences occurred ($\overline{X} = 17.4$) the amount of running showed no increase over sessions. As this result was not seen as attributable to suppression of run through competition with drink -- run did not increase with drink removed -- temporal contiguity was seen as insufficient.

This left response circumscription, response reduction, or both as necessary to reinforcement. Although the response requirement was seen as the "heart" of a contingency, Premack also saw response circumscription as an unavoidable consequence of contingent manipulations. The only condition that was free to vary within a contingency was the amount of the contingent response the organism could perform. Conditions were established that allowed the subjects to "drink the normal amount by running no more than the normal amount" (p. 170). In "three such studies involving 19 rats" (p. 171) no increase in running was observed.

Following this line of reasoning to its conclusion, it was now necessary to establish manipulations containing a reduction in contingent response performance relative to base performance. Such manipulations were found to reliably increase instrumental responding. Thus from the "suggestion that, specifically a reduction in H (higher probability responding) is needed in addition to temporal contiguity" (p. 171, parenthesis added), Premack moved to the statement, "an invariant though unrecognized component of the contingency is a decrement in the amount of responding that occurs to the contingent stimulus . . . Our results suggest that this reduction is vital, that reinforcement cannot be initiated without it" (p. 172).

Eisenberger, Karpman and Trattner (1967) were among the first to examine the status of the conditions pointed to as necessary and sufficient by Premack. College students were presented with two responses -- lever-pressing and wheel-turning -- in 10 min. sessions divided into 5 min. operant and contingency periods. Both responses were freely and simultaneously available during the operant period and the courses of responding, as well as total response durations, were recorded. The operant period was immediately followed by the contingency period in which both possible contingencies between the responses were presented to the subjects; wheel-turning for lever-press and lever-pressing for wheel-turn. In either case the contingent response was suppressed relative to its operant level. The results indicated that the "probability differential hypothesis" was not necessary to reinforcement as both contingencies led to increased instrumental responding. Eisenberger, et al., concluded that <u>response suppression</u> was the only condition essential to reinforcement, response suppression as expressed by the equation

$$\frac{I}{C} \times \frac{O_c}{O_i} > 1 : \qquad (2)$$

where I is the required amount of instrumental responding per contingency unit, C is the allowed amount of contingent responding per contingency unit, O_i is the operant level of the instrumental response, and O_c is the operant level of the contingent response.

Basing their work on Eisenberger, et al., Allison and Timberlake (1974; 1975) also challenged the probability differential hypothesis and pointed to <u>response deprivation</u> as the if and only if of reinforcement. Response deprivation is a condition "defined by (a) parameters of the contingency schedule, and (b) the operant level of each response" (1974, p. 231) such that the organism cannot perform the contingent response at its operant level if it performs the instrumental response at no more than its operant level. Mathematically, this is expressed as

$$\frac{I}{C} > \frac{O_i}{O_c} , \qquad (3)$$

where the symbols, identical to those of Eisenberger, et al. (1967), indicate more than conceptual similarity, the two formulae are exactly equivalent.

Although Premack (1971) never directly addressed the results of the studies by Allison and Timberlake (1974) or Eisenberger, et al., (1967), his restatement of the probability differential position retrenched his theory relative to those studies. Premack (1965, p. 158) presented data showing that the probability of a response was partially determined by the fashion in which the response was accessible: its continuity or discontinuity of access. Reinforcement procedures were seen as imposing "a discontinuity upon the availability of the contingent stimulus, a discontinuity which may affect the animal's probability of responding." Premack (1971) reasoned that studies in which the operant probabilities were determined with the responses continuously present and then presented these responses discontinuously during the contingency phase were possibly mistaken in the assumption that the operant probabilities held. This is perhaps best explained graphically

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INSERT FIGURE 1 ABOUT HERE

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by Figure 1. Given equality of a single episode of r_a and r_b, it can be seen that r_a is three times as probable, on the average, as r_b, since r_a occurs three times during the time period presented to r_b's single occurrence. Averaging over the entire time period, from point 0 to point t_3, the probability statement would be $\overline{P}(r_a) > \overline{P}(r_b)$. However, if we restrict our analysis to time section $(t_2 - t_3)$, then r_b is more probable than r_a and the momentary probability statement would be, $P(r_b) > P(r_a)$. Thus, if the operant assessment covered the entire period but the contingency restricted the occurrence of r_b to time period $t_2 - t_3$, then there would be a reversal of the probability relationship allowing for "a reversal of the reinforcement relation on a within-session basis" (Premack, 1971, p. 132); a reversal obtained by Eisenberger et al. (1967) and Allison and Timberlake (1974).

Mazur (1977, Exp. III) investigated the proposed relationship between probability and discontinuity by successively decreasing the accessibility of drinking over the course of sessions. Each 1000 sec. session was divided into 100 sec. cycles. After operant level was established the response was made unaccessible for the last 25 sec. of each cycle, then unaccessible for the last 50 sec. of each cycle and then it was removed for the last 75 sec. of each cycle before operant procedures were reinstated. Although total duration decreased with decreased access, probability increased with decreased access. His findings support Premack's probability-discontinuity contention.

Although Premack pointed to momentary response probability as a limiting condition of response deprivation theories, his differentiation between average and momentary response probability was made without any means of independently quantifying the momentary value (Dunham, 1977). Allison and Timberlake (1974) proposed that momentary response probability could be seen as either a) the unperformed amount of operant level performance ($O_i - NI$, $O_c - NC$) or b) the proportion of unperformed responding relative to operant level ($O_i - NI/O_i$, $O_c - NC/O_c$), where N is the number of repetitions of the contingency unit. For example, if I = 50 sec. and C = 10 sec., and the organism repeats the contingency unit 5 times (N = 5), then NI = 250 sec. and NC = 50 sec.

The first means of quantifying momentary response probability was seen as inconsistent with the evidence in that it generated predictions contrary to the observed data. Through analysis of observed and hypothetical data the second means of quantification -- the proportion of unperformed responding -- was found to generate corect predictions. Further, a mathematical relation between the two terms, was found to reduce to

$$\frac{O_c - NC}{O_c} > \frac{O_i - NI}{O_i} \qquad (4)$$

the response deprivation equation (Eq. 3). Asymptotic responding was seen as determined by the discrepancy between O_c and NC; instrumental performance attained maximum duration when N_c approached O_c provided the maintenance of Eq. 3.

Mazur (1975; 1977) explored this area with much the same method as Allison and Timberlake (1974; 1975) despite the differences in terminology and approach. Many of the experiments reported by Allison and Timberlake employed reciprocal contingencies in which the responses were singularly available and both contingent and instrumental to the other. In a typical reciprocal contingency the instrumental response is first made available, I of which must be performed for the contingent response to become available. The instrumental response is removed upon presentation of the contingent response. When C amount of contingent responding is performed the contingent response is removed and the instrumental response restored. And so on. This pattern of response availability and requirement is identical to that of interdependent conditions, the term used by Mazur. However, where Allison and Timberlake saw their results as composed of two dependent responses, Mazur saw his results as one complex response.

Mazur approached the response duration area by synthesizing the work of Premack (1965; 1971) with matching law formulations (Herrnstein, 1961; Baum & Rachlin, 1969). The duration of a response (T_a) relative to other response durations (T_o) was seen as directly proportional to the value of that response (V_a) relative to the value of all other responses (V_o) in that situation,

$$\frac{T_a}{T_a + T_o} = \frac{V_a}{V_a + V_o} \quad . \qquad (5)$$

In a conditioning preparation, with two target responses (r, d) under interdependent conditions, the performance of the new response (T'_{r+d}) was determined by a weighted summation of values,

$$\frac{T'_{r+d}}{T'_{r+d} + T'_o} = \frac{p(V_r) + (1-p)V_d}{p(V_r) + (1-p)V_d + V_o} \ ; \qquad (6)$$

where p, the rate of exchange or response proportionality, is determined by the parameters of the contingency,

$$p = \frac{T'_r}{T'_{r+d}} \quad . \qquad (7)$$

Thus if the contingency requires 50 sec. of d (T'_d = 50 sec.) and 50 sec. of r (T'_r = 50 sec.), then T'_{r+d} = 100 sec. and p = 0.5. An interesting prediction, given this analysis, is that contingent responding will decrease relative to baseline responding if $T'_d = T$ and $T'_r = T_r$.

This is interesting in opposition to Allison and Timberlake (1974; Timberlake & Allison, 1974) since the basic equation of their model does not address conditions where $I/C = O_i/O_c$. If, however, we speculate by examining Eq. 4 relative to the rate of exchange given no discrepancy between O_c and NC and correspondence between scheduled and operant performance, we could generate a prediction of no change. The proportion of the responses (O_i/O_c) would be maintained as well as obtained ($O_i - NI = 0$, $O_c - NC = 0$).

This deduction is identical to the prediction generated by the model of Rachlin and Burkhard (1978). The reasoning behind the predictions is not identical, but similar. Rachlin and Burkhard's basic conception is that responses are combined according to the maximum value (V) that can be obtained by the organism when restricted to a particular set of responses:

$$V=f(R_1, R_2, R_3, . . . R_n) = \text{max}. \quad (8)$$

Operant, or free responding, by definition, attains the maximum value. An effective contingency is one that restricts responding such that this combination cannot be attained. If the contingency decreases the performance of R_1, then at least one other response will substitute for the restricted response in such a manner that the new value is the highest possible under the contingent conditions. This new response distribution can be predicted, given an actual value function (power, hyperbolic, ellipsoidal), by determination of the substitutability of the unrestricted responses for the restricted response. The substitutability is given by the partial derivatives of these responses relative to the restricted response,

$$S_2^1 = \frac{df/dR_1}{df/dR_2}; \quad S_3^1 = \frac{df/dR_1}{df/dR_3}; \tag{9}$$

where S_2^1 is the substitutability of R_2 for R_1 and S_3^1 is the substitutability of R_3 for R_1. Increased instrumental performance occurs when the instrumental response is more readily substituted for the contingent response; when such substitution yields greater value than substitution of other responses for the restricted response. Decreased instrumental performance occurs when substitution of other responses for the restricted response results in greater value. No change relative to operant responding occurs when the contingency allows for the same combination of responses as observed in baseline.

Of the many points at which the above theories evidence disagreement only two are of importance to the present study: the importance of assessing changes in probability, relative to free access; and the function of a contingency in procedures designed to increase performance of a target (instrumental) response.

Non-contingent changes in probability (Premack, 1965; Mazur, 1977) are seen as a qualification of those results (Eisenberger et al., 1967; Allison and Timberlake, 1974; 1975; Allison, 1976) that utilize procedures based on average response probabilities. To an extent this concern underlies the position advanced by Timberlake (Note 1) in which associative effects (response changes due to the imposition of a contingency) and non-associative effects (discontinuous access and response substitution) were investigated to allow some means of separation. This issue can be translated into empirical methods in two fashions. The first would be to present the target responses in a discontinuous manner. This discontinuous access would allow for determination of response changes that could be expected simply because the contingency involves discontinuous presentation outside of its assumed function. The second manner would be to present the target responses in the same temporal pattern as a true contingency to assess changes resulting from this access pattern outside of the contingency. Despite the problems involved with yoking (Church, 1964) such procedures appear necessary.

The necessity of a yoked access control is further seen when the model of Rachlin and Burkhard (1978) is viewed as proposing that the if-then function of a contingency is secondary to the operation of response substitution. Whereas Timberlake (Note 1) views substitution as a control issue, Rachlin and Burkhard (1978) appear to argue that a contingency serves to control access in a systematic fashion and that increases in performance of the instrumental response result from its higher substitutability for the restricted, contingent response rather than the if-then arrangement enforced by the contingency. Yoked procedures are necessary to determine the accuracy of this position.

A secondary issue is related to the assumption that basepoint responding indicates maximal value of response combination. Rachlin and Burkhard propose that this be tested by imposition of a basepoint-proportion contingency. Given their view of contingency, however, it would seem that any procedure that does not preclude basepoint responding would be sufficient; provided that the responses, as in a contingency, are regularly accessible and inaccessible. Again, the underlying issue is whether discontinuous access by itself is sufficient to alter responding.

Method

Subjects

The subjects for this experiment were 24 male Holtzman rats (Madison, Wisconsin) approximately 90 days old at the start of procedures. They were individually caged and maintained on a 24-hour light cycle. They had 24 hour access to food and water except for one 24-hour period, prior to the first baseline session, during which they had no access to water.

Apparatus

Both experimental chambers (16 cm x 23 cm x 13 cm) were constructed of acrylic plastic, mounted on wooden bases and had wire grid floors raised 2.5 cm from those bases. The sides were opaque white, the fronts and tops clear. The two ports (2 cm) in front of each chamber were centered approximately 2.5 cm from the floor, 5 cm apart and 6.5 cm from the sides. A 7 watt light was mounted on the top of each chamber.

Clear acrylic plastic shutters were mounted on the front, containing one or two ports (2.5 cm). Movement of these shutters allowed or removed access to drinking tubes (0.8 cm od.) located 0.5 cm from the inside of the chamber and 0.5 cm below dead center of the chamber ports.

separated from the next by 24 hours. Each session began with the room lights being extinguished. The lights on top of the chambers were then turned on and access to the drinking tubes provided according to the type of session and group designation.

Prior to the first baseline observation, after two exploration sessions, a 24 hr period of no water access was imposed in order to facilitate subjects' acquaintance with the saccharin solutions. After this water was again continuously accessible. During the First and Second Baseline periods the groups received identical treatment. These sessions began with:

1) access to both solutions (solution position--right or left--randomly determined) for the entire session (paired access); or

2) access to only one solution, also randomly determined, for 50 sec then access to the other solution for 50 sec, and so on for the entire session (alternating access); or

3) access to only one solution for the entire session (single access).

In all, there were 30 paired access sessions, 7 alternating access sessions and two each of single access sessions for the 0.2% and 0.4% solutions. Baseline termination came when each subject demonstrated consistent response ordering for 3 sessions with the last session of those 3 being paired access and not followed by a 24 hr intersession interval.

After 41 baseline sessions the solutions were given fixed positions (the reasons will be discussed later) and the Contingency sessions were initiated. During these sessions:

1) CA subjects were given access to the 0.4% solution until I performance was attained (50 sec). They were then given C access to the 0.2% solution (10 sec). This pattern of access insured that I/C O_i/O_c;

2) YA subjects were presented with the solution access in temporal patterns identical to those of their CA squad partners; and

3) DA subjects had access to 0.4% solution until I performance was attained (50 sec). A period of no access followed this (10 sec) with return to 0.4% solution. The 0.2% solution was inaccessible for all contingency sessions and the tube was removed.

The second baseline period consisted of 4 additional paired access sessions for all subjects.

Results

As the overall pattern of experimental outcomes was of greatest interest, it was decided to maintain a 0.95 protection level across the experiment. For this reason, the per comparison error rate was set at 0.003 (Keppel, 1973). Therefore, no initial test based entirely on response data was considered significant that had a higher associated probability.

Mean response durations for the three groups by period and condition are given in Table 1. The groups' mean response durations by

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INSERT TABLE 1 ABOUT HERE

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session are plotted in Figure 2. To simplify presentation, the data

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INSERT FIGURE 2 ABOUT HERE

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will first be analyzed within each period (First Baseline, Contingency, Second Baseline) and, in the case of the First Baseline period, within each condition. Then the comparisons of responding between periods will be presented.

First Baseline Period

The First Baseline period consisted of three different access conditions; Single Access (SA), Alternating Access (AA), and Paired Access (PA). The data from each condition were first analyzed separately to insure that appropriate error terms existed for the tests of interest. Similarly, the data for each response were first analyzed separately. This procedure yielded six overall analyses: four single factor (Groups) tests (0.4% and 0.2% responding during SA conditions, 0.4% and 0.2% responding during PA conditions): and two 3x5 (Groups x Sessions) tests (0.4% and 0.2% responding during AA conditions). Only one of the ten F ratios given by this procedure attained significance: the sessions main effect for 0.2% lick durations during AA conditions, $F(4,84) = 9.67$, p .003. Subsequent analysis was both descriptive (trend analysis) and causal (orthogonal comparisons to determine the loci of the across sessions effect). The trend analysis indicated that the decrease in 0.2% licking was best described as linear, $F(1,84) = 33.85$, p .003. Orthogonal comparisons were performed using Scheffes' procedure and followed his suggestion to use a slightly larger error level to compensate for the conservative nature of these procedures. For these comparisons an error level of 0.01 was employed. These comparisons showed responding across the first three AA sessions to be roughly equivalent and greater than 0.2% licking during the last two AA sessions which were also statistically equivalent, $F(1,84) = 26.76$, $F_s = 14.6$.

At this point, comparisons between 0.4% and 0.2% responding, within conditions, were performed. For the SA and PA conditions data, correlated *t* tests were used. For the AA data comparison, the 0.4% response data was collapsed across groups and sessions, the 0.2% measures were collapsed across groups and then collapsed across sessions 36-38 and 39-40 in appreciation of the previous results. These collapsed measures were then entered into an analysis of variance for unequal *n* (Keppel, 1973). Conceptually, the comparisons are related to the notion of preference under differing conditions of comparison and competition.

When competition was not possible between the two saccharin solution responses, as under SA conditions, the subjects did not differentiate between the responses; they spent equivalent amounts of time drinking both. When the responses were presented within a procedure that precluded only direct competition, as under AA conditions, a preference did emerge $F(2,237) = 21.24$, $p < .003$; but this preference results from differences obtained between 0.4% drinking overall and 0.2% drinking in the last two (39,40) AA sessions ($F = 31.79$, $F_s = 13.83$). In the first three AA sessions (36-38), 0.4% and 0.2% drinking did not differ. If we assume that there is some limit to the amount of drinking that the subjects could perform within the given time boundaries, outside of the trivial limit of bounds, then the subjects must first learn some manner of comparing responses presented in sequential isolation. Only after this is learned can competition occur between those responses as to which will provide the majority of drinking time towards the limit. The sequential, isolated presentation accounts for this competition's indirect status. Under direct competition, or simultaneous presentation within an undivided time period (PA conditions), a preference for 0.4% licking clearly emerged, $t(23) = 10.8$, $p < .003$.

The last tests performed on First Baseline measures were comparisons within responses between conditions. Groups and sessions were collapsed across as above. In some cases comparisons on response duration and response probability measures were performed.

For 0.4% duration measures, two of the three comparisons attained significance. Performance during AA was significantly lower than SA performance, $F(1,138) = 90.83$, $p < .003$; AA performance was also reliably lower than PA performance, $F(1,138) = 32.28$, $p < .003$. This suggests, when combined with the rough equivalence obtained between SA and PA 0.4% response durations, that duration is a function of access -- as access is reduced, responding is reduced.

This picture changed when probabilities were examined. The average probability of 0.4% drinking ($\bar{P}_{(0.4\%)}$), under SA and AA conditions, 0.324 and 0.360 respectively, was not significantly different. The average probability of 0.4% drinking under PA conditions ($\bar{P}_{(0.4\%/PA)}$), 0.267, was also equivalent to that obtained under SA conditions. However, the average probabilities of 0.4% drinking under AA and PA conditions were significantly different, $F(1,138) = 13.89$, $p < .003$. This result serves to qualify the above access/response relationship. Although responding decreased as access decreased, the subjects reacted to decreased access with increased probablity; they drank for more of the available time.

The pattern of results when 0.2% drinking durations and probabilities were examined yielded roughly similar consistent suggestions. Mean 0.2% drinking duration was higher under SA than AA conditions, $F(2,141) = 95.78$, $p < .003$; subsequent orthogonal comparison showed SA 0.2% responding to be greater than AA 0.2% responding on sessions 36-38, $F(1,141) = 109.97$, $F_s = 14.16$. The overall analysis of average 0.2% drinking probabilities, $\bar{P}_{(0.2\%/SA)} = .292$, $\bar{P}_{(0.2\%/AA)} = .259$, was not significant; no further comparisons were made. The mean duration of 0.2% drinking during AA was significantly greater than under PA, $F(1,141) = 26.187$, $p < .003$. Subsequent orthogonal comparison showed AA 0.2% drinking on sessions 39/40 to be greater than during PA, $F(1,141) = 14.76$, $F_s = 14.16$. Given the relationship between duration and probability measures (Eq. 1) it was assumed that average response probability of 0.2% drinking during this subset of AA sessions would be significantly greater than that obtained under PA conditions ($\bar{P}_{(0.2\%/PA)} = 0.07$). It was further assumed that any comparison of 0.2% measures between SA and PA conditions would be significant. For this response (0.2% drinking) there again appears to be a directly proportional relationship between access and responding. However, for 0.2% drinking this relationship is qualified not by probability but by competition. As access was increased (AA to PA) while a preferred response was introduced within the response set, allowing direct competition, both duration and probability of 0.2% drinking decreased.

In summary, the results of the First Baseline period suggest that responding is functionally related to response access and competition; or, responding is related to time constraints and the characteristics of the presented response set. For a preferred response, here 0.4% drinking, the most important factor was access. For a nonpreferred response, 0.2% drinking, both access and competition were seen to have significant impact on some aspects of responding.

Contingency Period

There were no significant results obtained from analysis of the Contingency period response measures. The 3x8 (Group x Sessions) analysis of 0.4% data and 2x8 (Group x Sessions) analysis of 0.2% data yielded insignificant main effects and interactions. A separate analysis of the 0.4% duration measures on Session 46 was also insignificant. This indicates that the groups' initial performance remained relatively constant across the Contingency period and that this level of performance was equivalent across groups. In short, the Contingency period manipulations failed to have any effect on behavior.

Comparison between 0.4% and 0.2% responding was not performed as the access conditions during the Contingency period were designed so that operant performance was significantly modified. Any such comparison would be trivial for this reason.

Second Baseline Period

No significant results were obtained with 0.4% drinking duration or probability measures. The groups, again, were statistically similar in their performance and maintained these performance levels over the Second Baseline period.

For 0.2% response data, a significant Sessions main effect was obtained. $F(3,63) = 5.55$, $p \cong .003$. Descriptive (trend) analysis showed the decrease in 0.2% drinking duration measures to have both linear, $F(1,63) = 10.89$, $p < .01$, and quadratic components, $F(1,63) = 5.59$, $p < .025$. Orthogonal comparison indicated that 0.2% drinking on Session 50 was significantly greater than on the remaining sessions, $F(1,63) = 16.26$, $F_s = 12.39$, which were similar. As Figure 2 shows, 0.2% drinking underwent a sharp initial decrease followed by a slight increase.

The difference between 0.4% and 0.2% drinking was assumed to be reliable.

First Baseline and Contingency Period Comparisons

Comparisons between First Baseline and Contingency period measures were performed by collapsing across groups and, where appropriate, sessions and then subjecting the collapsed sums and resultant means to analysis of variance for unequal *n* (Keppel, 1973). This procedure is held to increase the power of the individual tests. Of the three comparisons performed on the 0.4% drinking duration measures only that between AA and Contingency performance was significant, $F(1,308) = 107.29$, $p < .003$. Again, this indicates that the reduced access to 0.4% drinking under AA conditions served to reduce the amount of 0.4% drinking. The lack of significance, especially between PA and Contingency performances further highlights the ineffectiveness of the contingent manipulations. Reinforcement, or instrumental performance, did not obtain.

As 0.2% drinking was lowest under PA conditions, these measures were first compared with contingency performance. If insignificant, AA performance on Sessions 39/40 would have been compared with Contingency period 0.2% drinking; and so on should this test have been insignificant. Given the heterogeneity of variance between PA and Contingency 0.2% drinking, a conservative *F* test (Edwards, 1972) was performed. This test was significant, $F(1,14) = 316.29$, $p < .003$, and indicated that the contingency had decreased 0.2% drinking relative to its operant level. No further comparisons of 0.2% responding were made.

Thus, the contingent manipulations decreased the amount of contingent performance (0.2% drinking) without having produced increased instrumental performance (0.4% drinking).

First Baseline and Second Baseline Period Comparisons

Collapsing the 0.4% measures in the same fashion as above, the differences between Second Baseline 0.4% drinking and 0.4% drinking obtained under SA and PA conditions were unreliable. The third comparison between AA 0.4% drinking and Second Baseline period responding was significant, $F(1,210) = 38.33$, $p < .003$. Once again, this indicates the reliability with which 0.4% drinking could be decreased by alternating access.

For the 0.2% response data, comparisons involved first collapsing across groups and equivalent sessions and then proceeding in the stepwise fashion indicated previously. An overall comparison of First Baseline PA 0.2% drinking with Second Baseline 0.2% drinking was significant, $F(2,117) = 7.81$, $p < .003$. Subsequent orthogonal comparisons, again using Scheffes' criteria, indicated that the focus of this significant result was the difference between PA and Sessions 51-53 0.2% drinking (duration measures), $F(1,117) = 15.19$, $F_s = 9.58$. From these results, it was assumed that AA 0.2% responding was significantly greater than Second Baseline 0.2% drinking. In summary, the subjects' immediate post-contingency responses under paired access were indistinguishable from their immediate pre-contingency 0.2% responses. By the second post-contingency session, 0.2% drinking decreased sharply compared to pre-contingency performance. Further, it remained decreased, despite a slight increase towards the end of the period in quesiton.

Contingency and Second Baseline Period Comparisons

For the 0.4% drinking measures, comparison was performed on the data after it was collapsed across groups and respective sessions. There were no differences between Contingent and Second Baseline 0.4% drinking.

For 0.2% measures, an overall comparison was performed between Contingency, Session 50, and Sessions 51-53 data collapsed across groups. Measures from all three groups were included in the Second Baseline period. The overall analysis, again a Conservative F, was significant, $F(1,71) = 40.13$, $p < .003$. Subsequent orthogonal comparisons showed this outcome to result from the difference between Contingency and Session 50 0.2% duration measures, $F(1,71) = 70.14$, $F_s = 21.24$. When freed from the constraints of the Contingency period manipulations, 0.2% drinking regained its pre-Contingency performance level. By the second such session 0.2% drinking decreased to a level of performance slightly higher than, but nevertheless similar to, Contingency performance.

Discussion

The numerous statistical results -- both significant and nonsignificant -- and their associated suggestions can be reduced to a few general statements using the response pattern from Session 41 (PA -

First Baseline) as the referent point. The first, and most troublesome, is that the Contingency period manipulations failed to produce any reliable group differences and, despite a significant reduction in contingent responding, also failed to produce instrumental performance. Reinforcement was not obtained. Secondly, where differences were obtained, the direction of that change depended upon the response under consideration, the measure employed for comparison, and the conditions of competition. Lastly, there is the decrease in 0.2% drinking over the present study; the possible function of which will be discussed later.

That reinforcement was not obtained is an obvious impediment to discussion of reinforcement within a response based framework. It is, perhaps, even a greater impediment to a discussion of the accuracy with which the various models of reinforcement predicted the obtained results. It is difficult to come to resolution about predictive accuracy when that which was to have been predicted did not occur.

Before considering, in length, what did not occur, some discussion of what did occur seems timely as the process of reinforcement is only one aspect, albeit the dominant aspect, of response based theories of behavior. The present investigation can address non-contingent modification of behavior patterns as well as older arguments (Premack, 1965) and newer arguments (Timberlake, Note) concerning appropriate operant procedures. The most general statement here is that any change in the conditions of access -- including the number and probabilities of accessible responses -- can serve to alter the "operant" levels of the target responses. With higher probability responses one can increase or decrease the operative levels dependent upon the employed measure and the change in access (Premack, 1965; Mazur, 1977). One can obtain equivalent responding from responses that under different conditions are clearly of different probabilities. And competition appears as a one-sided phenomenon; it seems to decrease only lesser probability responses. Timberlake (Note 1) has addressed these sorts of effects in much greater depth in his investigation of operant measures. The present outcomes suggest, relative to that research, that the order of access conditions may have effects that are of as yet unknown duration so that attempts to obtain baseline levels after the contingency period may be even more problematic than such attempts prior to contingent manipulations.

The operation of order effects is one possibility for the present failure of contingent manipulation effectiveness. During AA conditions the subjects may have learned that access was response independent and that the brief pre-contingency PA condition was insufficient to allow for extinction of this conditioning. It may be that under AA conditions the subjects were somehow, surreptitiously reinforced for not engaging in 0.2% licking and that this learning worked against any subsequent conditioning based on 0.2% deprivation. It is impossible to assess order-related effects or eliminate them as a possible reason for the failure to obtain reinforcement in the present study.

A second possible reason for failing to obtain reinforcement is the apparent instability of 0.2% drinking over the course of the present investigation. The decrease in 0.2% drinking seen over the First Baseline period may have been in line with the contingency schedule such that deprivation during the Contingency period, documented by several measures, was insufficient. In other words, the contingency served to impose temporal controls on the subjects responding but did not fully meet the requirements of Eq. 3.

One result that supports this argument is the comparability of 0.2% drinking obtained under contingent manipulations and at the end of the Second Baseline period.

Counter arguments are the significant decrease between First Baseline, PA and Contingent period 0.2% performance, and that 0.2% responding as projected by the regression line for Sessions 36-41,

$$Y = 107.49 - 10.37\,X, \qquad (10)$$

where Y = 0.2% drinking and X = sessions, exceeded obtained 0.2% drinking over the first four Contingency sessions. It is also true that statistical analysis did not indicate any differences in 0.4% drinking over the Contingency period. However, the absence of appropriate control subjects -- receiving paired access conditions during the Contingency period -- makes it impossible to eliminate this criticism.

A third possible reason for the failure to obtain instrumental performance may stem, in some fashion, from response bias introduced by fixing the solution positions past Session 41. Prior to this session, solution position was randomly determined; it happened that the positions for Sessions 39-41 were identical. It was over these sessions that baseline termination criteria were met. Given the tendency for some subjects to reverse their response preference with reversal of satisfaction of Eq. 3, this theory predicts, in ordinal fashion, instrumental performance through the following formula:

$$D_c = O_c - \frac{O_i C}{I} \qquad (11)$$

With $O_i:O_c$ constant, different levels of asymptotic instrumental performance are specified by Eq. 11 given different I:C values; actual asymptotic durations are not explicitly specified. Similar predictions are obtained with I:C constant and $O_i:O_c$ varied. The necessary com- parative base for prediction did not exist, but as contingent depriva- tion was imposed and instrumental performance was not obtained, the theory is unsupported.

However, it may be equally true that the theory was not addressed as it is unclear that Eq. 3 was satisfied. One can advance the previous arguments concerning the trend and various comparisons in 0.2% responding for both sides of the question. And as before, these arguments are insufficient to resolution. Timberlake and Allison (1974) do not address response modification outside of contingent access conditions and so this aspect of the present study offers nothing in terms of their position. For all these reasons, the theory notion of response deprivation cannot be meaningfully evaluated here.

Such is not the case with Mazur's (1975; 1977) model which yielded quantitative predictions for each CA subject's asymptotic level of instrumental performance. This model predicted instrumental responding significantly below its obtained level, $\underline{t}(7) = 4.05$, $\underline{p}$ .01. This under-prediction is an acknowledged problem (Mazur, 1975) and the later presentation (Mazur, 1977) attempted to locate various sources of noncontingent modification of response probability, similar in nature to the present study's procedures, to account for under prediction. If Eq. 7 is modified to incorporate the higher probability of 0.4% responding under alternating access, a second set of predictions is generated that did not differ from obtained performance, $t(7) = 1.92$, $p > .05$.

This goodness of fit is only apparent; some underlying problems exist. The model is not, as yet, formulated to account for the overall group similarities during the Contingency period. However, given that reinforcement was not obtained, this point is not crucial. Of more importance, conceptually, is that modification to increase the level of predicted instrumental performance was consistent with obtained responding that was not indicative of reinforcement; a result seemingly incongruous for a model of reinforcement. This serves to emphasize the point mentioned by Rachlin and Burkhard (1978) that reinforcement must entail increased duration; proportional increases are insufficient. To be fair, Rachlin and Burkhard (1978) and Mazur (1975; 1977) address different sets of contingent access conditions so that the different means of quantifying reinforcement may be fully justified relative to those access conditions.

Predicted - obtained relationships are more difficult to evaluate within the model given by Rachlin and Burkhard (1978) as they only specify the conditions a theory must meet to be consistent with their position. The predictive process becomes immediately demanding as a given "basepoint" is consistent with a number of mathematical functions. As an example, in a two response (2 dimensional) system, the basepoint (1,1) can represent linear ($Y = aX + b$), exponential ($Y = aX^n + b$), or hyperbolic functions ($Y = \frac{X}{a} + b$). Prediction, therefore, is specification of different function sets -- in the absence of other determining criteria -- such that asymptotic performance is restricted to as many points as there are possible functions. Here, the "correct" prediction could only have been determined with both fore- and hindsight.

Use of a linear theory consistent with the general model,

$$V = aC + bI + cN, \quad (12)$$

where a, b, and c are constants and N symbolized non-target responding, yielded sets of coefficient values for mean CA group performance with best basepoint approximations at $a = 0.15$ or $a = 0.17$. At these values substitutability of I for C was greater than that of N for C, leading to the prediction that I would substitute for the reduction in C. Again, this was not the case.

A secondary issue addressed by the present study is this model's assumption that basepoint responding reflects the maximum value to be obtained within a given response set under certain conditions of access. One implication of this assumption is that basepoint proportionality should be obtained under conditions that do not preclude this proportionality. Alternating Access represented conditions that differed from unrestricted, paired access without precluding basepoint responding. Basepoint proportionality was not obtained under Alternating Access. It is the case that responding at this point may not have been stable nor was the test of this assumption performed, as suggested by Rachlin and Burkhard, under contingent access conditions. But given the findings of Premack (1965), Mazur (1977) and the present study, the validity of this assumption is questionable. Timberlake's (Note 1) theory was additionally examined because of its conceptual similarity to the present investigation. It should be noted that this theory deals with learning as evidenced by performance while the previous theories and models are concerned only with performance. As mentioned earlier, Timberlake attempted to separate associative and non-associative performance increments when the target responses evidenced high substitutability or "unlearned functional and topographical similarity" (P. 3). On the whole, each CA subjects' predicted performance exceeded obtained performance, but not significantly so, $t(7) = 0.96$, $p > .05$.

There are problems despite the agreement between predicted and obtained performance. Most important here is that for some CA subjects instrumental performance decreased during contingent manipulations; a problem acknowledged by Timberlake (Note 1) as there "is no provision in the model . . . for the possibility that a subject will lick less" (p. 16). This theory at present is limited to response modifications within contingent access manipulations; it does not address the noncontingent modification found here.

And so, the attempts to explain the present results are hampered for any number of reasons; in the main, the lack of reinforcement was telling. But at this point it is also noticed that the focus has been narrowed to only one means of obtaining and assessing response modification through some form of contingent manipulation. Obviously, reinforcement as a process, is of immense importance as it is implied to exist given any evidence of learning. But recent studies have shown that other factors can reliably lead to response modification. So, a theory of behavior must be able to address more than reinforcement effects.

It may also be necessary for that theory to expand its conceptions of the conditions that contribute to reinforcement effects. If Premack (1965) is taken as the originator of response probability theory, than subsequent investigators have focused on the necessity of the probability differential hypothesis and the nature of contingent access conditions required to produce increased instrumental responding. The other major surplus condition - response circumscription - has not received similar attention although it has been investigated as "freedom of choice" (Mazur, 1977).

One argument for a theory premised on response circumscription (Dunham, 1977), consistent with the retrenchment of Premack (1971) is that cumulative measures, however valid, do not provide a fine enough analysis of behavior. Or, from another perspective, information is lost with cumulative measures and theories based on cumulative measures are therefore limited in their analyses. As an example, assume $P(r_a) = 0.43$. This leads to the generation of two, related expectations for r_a consistent with probability duration translations:

1) that R_a, on the average, occurs for 43 of 100 sec., and
2) that r_a has a 0.43 probability of occurrance at any given time.

Does R_a occur all at once? If not, in how many episodes does r_a occur and are these occurrences regularly spaced? These questions cannot be answered by knowing only that $P(r_a) = 0.43$.

It may also be of value to realize that if $P(r_a) = 0.43$, then for 43 out of 100 sec. the actual probability of r_a is 1.00; r_a, in fact, occurs. And that for 57 of 100 sec. r_a does not occur, suggesting that its probability may be very much less than 0.43. The extension of this argument at this point is that some method of quantifying momentary probability, outside of restrictive assumptions (e.g., strictly linear, Allison & Timberlake, 1974), might profitably be investigated.

The second extension of the above perspective is that previous theories by use of gross measures in the analysis of one aspect of behavior have been good but needlessly limited--without sufficiently broad focus. And such focus seems necessary, given the results of research that has found no connection between different measures of a response system (Miller, 1956) or has provided evidence of compensation within response systems without investigation of the mechanism(s) of that compensation (Collier, Hirsch, & Hamlin, 1972; Allison, 1976). It is only by insisting on finer analysis that such phenomenon may come to be understood.

TABLE 1.

Mean Lick Durations by Group and Access Condition

	ACCESS CONDITION									
	Single		Alternating		Paired (1st)		Contingent		Paired (2nd)	
GROUP	0.4%	0.2%	0.4%	0.2%	0.4%	0.2%	0.4%	0.2%	0.4%	0.2%
Discontinuous Access	203.4	164.8	102.9	75.7	162.6	32.5	165.7	--	157.3	20.3
Contingent Access	197.9	163.6	116.2	74.8	166.3	37.0	176.1	3.9	183.3	19.6
Yoked Access	183.6	197.5	105.9	81.9	152.7	49.0	181.2	3.9	172.1	20.8
Overall	195.0	175.3	108.3	77.5	160.5	39.5	175.7	--	170.9	20.2

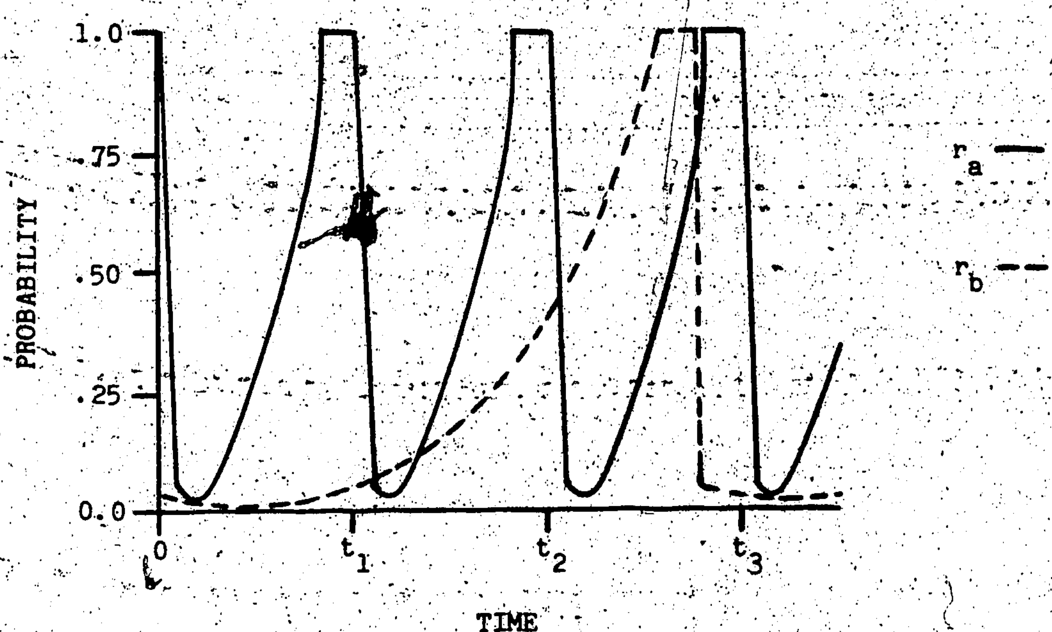

Fig. 1. Hypothetical probability-time paths for two responses.

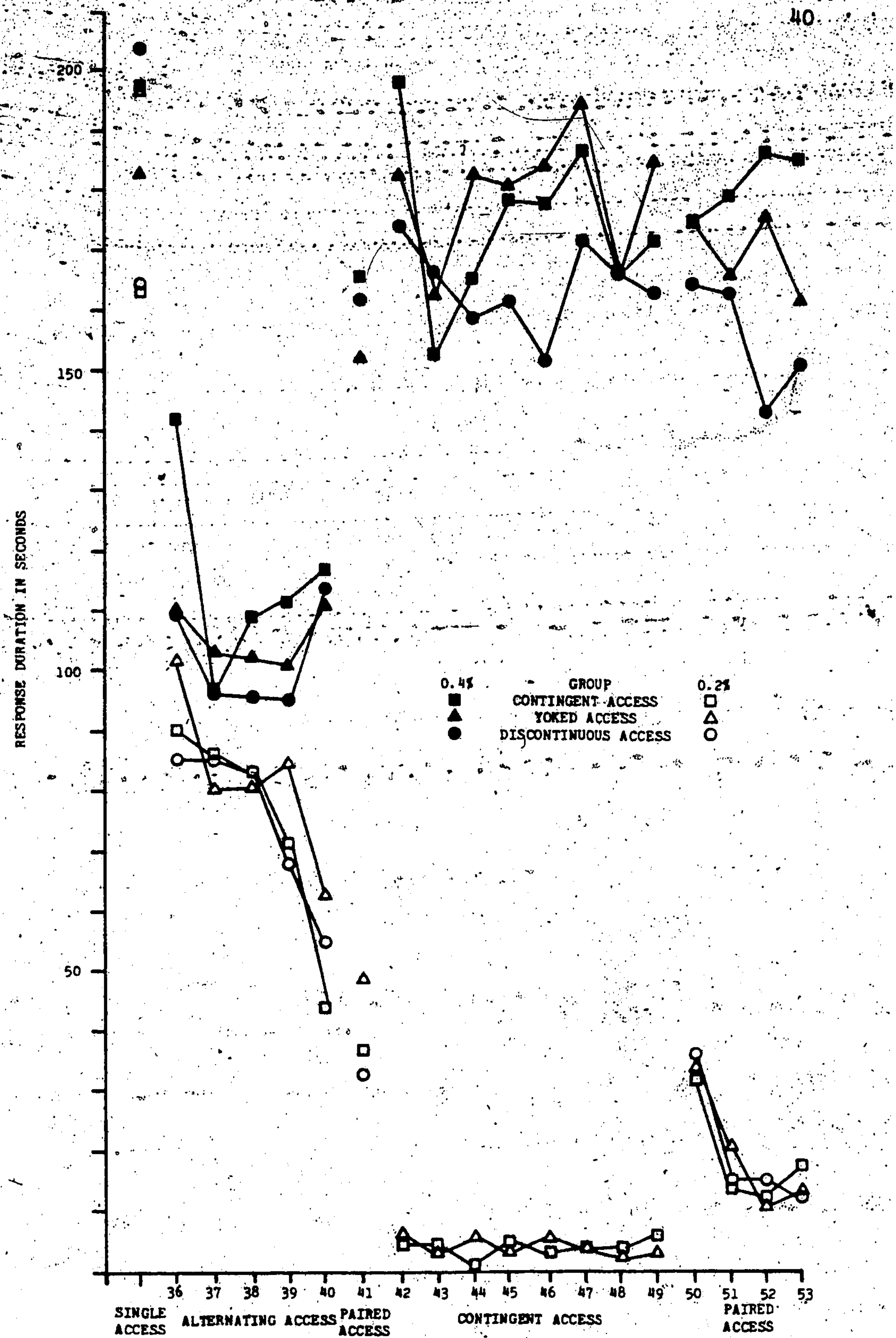

Fig. 2. Group mean 0.4% and 0.2% responding by sessions.

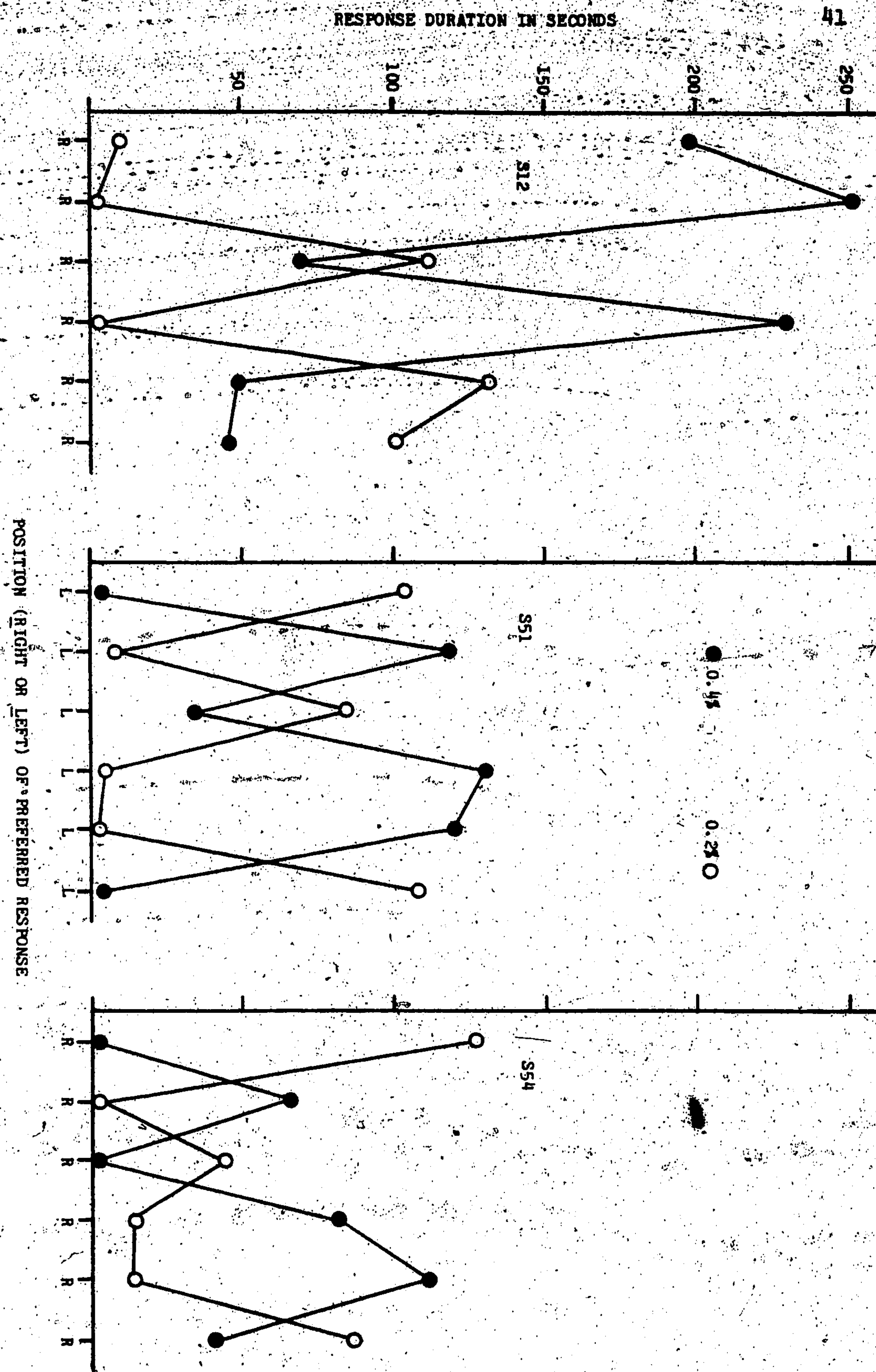

Fig. 3 Examples of positional response preference (bias).

Reference Notes

1. Timberlake, W. Licking one saccharin solution for access to another: Associative learning or substitution? Paper presented at the American Psychological Association Convention, San Francisco, 1977.

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