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RESPONSE DEPRIVATION AND REINFORCEMENT IN APPLIED SETTINGS: A PRELIMINARY ANALYSIS

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First-grade children engaged in seatwork behaviors under reinforcement schedules established according to the Premack Principle and the Response Deprivation Hypothesis. Across two experiments, schedules were presented to the children in a counterbalanced fashion which fulfilled the conditions of one, both, or neither of the hypotheses. Duration of on-task math and coloring in Experiment 1 and on-task math and reading in Experiment 2 were the dependent variables. A modified ABA-type withdrawal design, including a condition to control for the noncontingent effects of a schedule, indicated an increase of on-task instrumental responding only in those schedules where the condition of response deprivation was present but not where it was absent, regardless of the probability differential between the instrumental and contingent responses. These results were consistent with laboratory findings supporting the necessity of response deprivation for producing the reinforcement effect in single response, instrumental schedules. However, the results of the control procedure were equivocal so the contribution of the contingent relationship between the responses to the increases in instrumental behavior could not be determined. Nevertheless, these results provided tentative support for the Response Deprivation Hypothesis as a new approach to establishing reinforcement schedules while indicating the need for further research in this area. The possible advantages of this technique for applied use were identified and discussed.

DESCRIPTORS: Premack Principle, Response Deprivation Hypothesis, academic behavior, reinforcement, contingencies

The traditional approach to reinforcement taken by applied researchers has been a pragmatic one guided by the Empirical Law of Effect (Skinner, 1935; Spence, 1956). This law labels a stimulus as a reinforcer if its presentation after a response produces an increase in that behavior. An alternative to this empirical method of defining and selecting reinforcing events was provided by Premack in 1959. Rather than relying upon post hoc observations of effectiveness, Premack hypothesized that a reinforcing event could be viewed as a response and defined a priori by focusing upon its relation to the behavior to be increased (i.e., the instrumental response) in a free-performance (baseline) situation. The relative probabilities of these responses were believed to be the key to the occurrence of a reinforcement effect. That is, within a particular schedule, the reinforcement effect will be shown only if the behavior with the higher free-performance probability serves as the contingent response and the lower-probability behavior as the instrumental response (Premack, 1959).

Subsequently, the outcome of a number of experimental studies have appeared consistent with this Probability Differential Hypothesis, or so-called Premack Principle (e.g., Premack, 1963, 1965, 1971; Schaeffer, Hanna, & Russo, 1966; Wasik, 1969). Encouraged by these findings, and perhaps by the simplicity and economy

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of the hypothesis, applied researchers have successfully utilized the concept of probability differential to select reinforcers for use in clinical programs (e.g., Ayllon & Azrin, 1968; Bateman, 1975; Danaher, 1974; Hartje, 1973; Homme, deBaca, Devine, Steinhorst, & Rickert, 1963; Mitchell & Staffelmayr, 1973; Wasik, 1970). Unfortunately, applied behavior analysts virtually ignored another important variable noted by Premack (1965) as relevant to understanding instrumental performance. This variable is the suppression of contingent responding relative to its baseline level that inevitably occurs in schedules that produce a reinforcement effect.

The importance of such suppression of contingent responding in reinforcement schedules was documented in the laboratory by Eisenberger, Karpman, and Trattner (1967). These researchers provided strong evidence that this variable was the necessary and sufficient condition for reinforcement. This was done by demonstrating that the reinforcement effect could be produced even when a lower-probability behavior served as the contingent response if the schedule requirements produced a suppression of contingent responding relative to its baseline level. This finding, which was in direct conflict with the general postulation of the Premack Principle concerning the necessity of an appropriate probability differential, has been supported by the results of a number of recent laboratory investigations (Allison, Miller, & Wozny, 1979; Allison & Timberlake, 1974; Bernstein, 1974; Heth & Warren, 1978; Timberlake & Allison, 1974).

On the basis of such findings, Timberlake and Allison (1974) developed the Response Deprivation Hypothesis of instrumental performance. This conception resembles the Premack Principle in that the freely occurring levels of instrumental and contingent responding are important determinants of schedule effectiveness. However, in contrast to the Premack Principle, the Response Deprivation Hypothesis stipulates that the reinforcement effect will occur only when the terms of the schedule result in reduced access to the contingent response relative to its baseline level if the subject performs the instrumental response at or below its baseline level (Timberlake & Allison, 1974). Thus, effective contingencies require the subject to increase instrumental responding in order to alleviate the "deprivation" of the contingent response produced by the schedule requirements. Mathematically, the condition of response deprivation is said to exist in a contingency if $I/C > O_i/O_c$, where I and C are the terms of the instrumental and contingent responses in the schedule condition while O_i and O_c represent their respective freely occurring levels. In essence, response deprivation is present in a schedule only when the ratio of the instrumental response to the contingent response is greater in the contingency than in the operant baseline. It is important to note that this condition is determined in an antecedent fashion through the judicious selection of schedule requirements after examining the free-performance levels of the instrumental and contingent responses.

The relationship between the Probability Differential and Response Deprivation Hypotheses and the various predictions of instrumental performance they make are readily seen by way of example. Assume that two behaviors, A and B, have paired-operant baseline (where both responses are continuously and freely available) levels of 10 and 5 units, respectively. Table 1 presents three illustrative schedules based on these behaviors. According to the Premack Principle, Schedules 1 and 2, but not 3, will produce the reinforcement effect because only in those schedules does the higher-probability behavior serve as the contingent response. On the other hand, the Response Deprivation Hypothesis predicts the reinforcement effect whenever the condition of response deprivation ($I/C > O_i/O_c$) is produced by the schedule requirements. In the example, response deprivation is present only in Schedules 2 and 3 ($5/1 > 5/10$ and $5/1 > 10/5$). This means that in these schedules, con-

Table 1
Sample Schedule Requirements

Paired-Operant Levels: Behavior A = 10, High Probability Behavior (HPB)
Behavior B = 5, Low Probability Behavior (LPB)

	Instrumental Response (I)	*Contingent Response (C)*	*I/C*	O_i/O_c	*Theory Predicting Reinforcement*
			B/A	O_b/O_a	
Schedule 1	B	A	1/5	<5/10	Premack Principle
	(LPB)	(HPB)	.2	.5	
			B/A	O_b/O_a	Premack Principle,
Schedule 2	B	A	5/1	>5/10	Response Deprivation Hypothesis
	(LPB)	(HPB)	5	.5	
			A/B	O_a/O_b	
Schedule 3	A	B	5/1	>10/5	Response Deprivation Hypothesis
	(HPB)	(LPB)	5	2	

tinued performance of the instrumental response at its baseline level would deprive the subject of access to an operant level of the contingent response. Consequently, increased instrumental performance is expected in order to reduce that deprivation. On the contrary, in Schedule 1, the subject would still be provided access to the contingent response at its accustomed level by continuing to perform the instrumental response at its baseline level. Hence, no increase of instrumental performance is predicted by the Response Deprivation Hypothesis. So although the two hypotheses make convergent predictions concerning the effects of Schedule 2, they clearly conflict regarding Schedules 1 and 3. That is, according to the Response Deprivation Hypothesis a higher-probability contingent response may *not* produce a reinforcement effect (e.g., Schedule 1) whereas a lower-probability contingent response could (e.g., sample Schedule 3), depending on the presence of response deprivation.

Thus, according to the Response Deprivation Hypothesis, any response already in the behavioral repertoire of the subject is a potential reinforcer given the presence of response deprivation in the schedule. This hypothesis has significant implications for the behavior modifier in that it would provide a new and rich source of reinforcers beyond those traditionally employed if its applied validity is demonstrated.

In this study, the validity of the Response Deprivation Hypothesis was examined in the context of an educational setting. Specifically, the implication that under appropriate conditions any response, regardless of its relative probability, can serve as a reinforcer for another response was tested. This was accomplished by assessing the convergent and divergent predictions of the Premack Principle and Response Deprivation Hypothesis noted above. Although such comparisons of models are being performed in basic learning laboratories (e.g., Allison et al., 1979; Timberlake & Wozny, 1979), similar tests in applied settings have not yet been conducted. Consistent with laboratory findings, it was hypothesized that the condition of response deprivation, but not probability differential, would be required to establish effective reinforcement schedules.

EXPERIMENT 1

Experiment 1 assessed the prediction that a lower-probability behavior can act as a reinforcer for a higher-probability behavior when the conditions of response deprivation are present but not when they are absent (cf. Allison & Timberlake, 1974).

METHOD

Participants and Setting

Two first-grade children, Dave and Fifi, enrolled in an inner-city, low SES neighborhood public school, participated in the study. The teacher described them as being of average intellect and as presenting no particular behavioral problems. The experiment was conducted at a small table in the back of the children's regular classroom.

Tasks and Materials

Typical classroom coloring and math tasks were selected as target behaviors. Math responses consisted of matching numbers, filling in missing numbers, and working one-digit addition and subtraction problems. Two books from the Whitman coloring series were used for the coloring task. Pencils, crayons, and other necessary academic materials were supplied by the classroom teacher.

Definitions, Recording, and Reliability

Response duration was the unit of measurement in this study in order to be consistent with Premack's (1965, p. 134) requirement for between-response comparison. Math and coloring were defined in the following manner:

On-task math: Child in seat at work table, gaze directed toward work materials obtained from math tray and/or manipulating these materials. Includes counting on fingers or counter.

On-task coloring: Child in seat at work table, gaze directed toward coloring book or crayons obtained from coloring tray and/or manipulating books or crayons.

During the sessions, the experimenter recorded the length of time a child spent on each task. A stopwatch ran continuously throughout the 20-min session. The experimenter recorded each contact with a task by noting the time of the onset and offset of each contact. If the child was not in contact with one of the tasks, the experimenter recorded nothing.

Seven reliability checks were conducted for each child with at least one check per experimental condition. Reliability for each of the on-task behaviors was assessed by one of two raters (a graduate student in psychology or the classroom teacher) who observed the session along with the experimenter. Reliability of recording on the total daily duration of each on-task behavior was calculated by taking the total duration per session of each task in seconds, for the rater and the experimenter, dividing the smaller number by the larger, and multiplying by 100 (Kelly, 1977). On this measure, math and coloring both averaged 98% agreement with ranges of 97 to 100% and 91 to 99%, respectively.

In addition to reliability on the total duration of responding, a finer assessment of recording was completed. For purposes of reliability only, the session was divided into 10-sec intervals, and the data of the experimenter and the rater were compared to note agreement of occurrence in each of those intervals. Reliability was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100 (Kelly, 1977). On this measure, math averaged 98% agreement with a range of 96 to 100%. Coloring averaged 99% with a range of 98 to 100%.

Design

The two schedules evaluated in this experiment, RD (response deprivation present) and $\overline{\text{RD}}$ (no response deprivation present), were presented to the children in a counterbalanced fashion. Before each of the schedule conditions, the children were presented their two tasks in a paired-operant baseline (BL) to evaluate their freely occurring levels. Following each RD and $\overline{\text{RD}}$ schedule, a matched-control condition (MC) was implemented to assess the effects upon instrumental responding of restricted access to the contingent behavior in the absence of a contingent relationship between the responses (Bernstein, 1974; Bernstein & Ebbeson, 1978). In summary, Dave's order of conditions was BL, RD, MC, BL, $\overline{RD}$, MC while Fifi's was BL, $\overline{RD}$, MC, BL, RD, MC.

Procedures

The sessions were conducted early in the afternoon each day as the school schedule permitted. The experimenter brought each child individually to the work table at the back of the classroom where all the task materials were kept in labeled trays. After being seated, the instructions were read by the experimenter who then remained at the work table and recorded the behavior of the child. The experimenter did not interact with the child once the session began and ignored any interaction initiated by the child.

Baseline (BL). In this condition, the math and coloring tasks were freely and continuously available to the children. The trays containing the tasks were easily reached by the children and were alternately positioned on the table each day to control for any possible left-right preferences. Before each session, the experimenter made the following statement to the children:

> "Hi, *Name*. Today you are going to work at this table. Stay in the chair until I tell you that you may get up. On the table are two trays, one with math seatwork and one with coloring work. You can work on whichever one you wish, the math or the coloring for as long as you want, it's up to you. Do whatever you want. The only rules are that you stay in your seat, you must not talk to me, keep all papers in their own tray, and work on only one task at a time."

(Adapted from Butcher & Osborne, Note 1) These were the only instructions. No intrasession instructions or feedback were given to the children at any time. After 20 min elapsed, the children were told to return to their seat and were thanked for their cooperation.

Schedule conditions (RD, $\overline{RD}$). During these conditions, each child was brought to the table as during baseline and the following statement was read:

> "Hi, *Name*. Today you are to work at this table. Stay in the chair until I tell you that you may get up. Remember, the rules are that you can only work on one task at a time, you must keep the materials in their own tray, and you must not talk to me."

Initially, only the instrumental response materials were on the table in front of the child. When the child completed the instrumental requirement of his or her schedule, the materials of the contingent response were placed on the table for the amount of time indicated by the schedule (C). No other interaction occurred, and any attempts by the child to interact with the experimenter were ignored. The instrumental response materials also remained available to the child; however, instrumental responding at this time did not count toward satisfying the instrumental requirement (I). Instrumental responding was effective in completing the schedule only when the contingent response was unavailable. When the allotted time for the contingent response expired, regardless of the amount of time the child actually engaged in it, these materials were removed and not reintroduced until the child had once again fulfilled the instrumental requirement. The schedule requirements were not communicated to the children.

The first step in establishing the reinforcement schedules was the determination of the higher- and lower-probability behaviors by examining the paired-operant levels of coloring and math. Coloring was shown to be the higher-probability behavior and served as the instrumental response while math, the lower-probability behavior, served as the contingent response. The second step was establishing the O_i/O_c ratio for each of the children based on their respective average daily duration of math and coloring in baseline. Finally, the I/C ratios were determined so that $I/C > O_i/O_c$ accurately described the schedule in the RD conditions and

Table 2

*Schedule Requirements—Experiment 1

Dave	BL O_i/O_c	RD I/C	MC C**	BL O_i/O_c	$\overline{RD}$ I/C	MC C**
# of sessions	6	5	5	5	6	6
Color/math	12.1/7.5	5/2	2	13.5/6.1	1/4	4
ratio	1.6	2.5	–	2.2	.25	–

Fifi	BL O_i/O_c	$\overline{RD}$ I/C	MC C	BL O_i/O_c	RD I/C	MC C
# of sessions	6	5	5	5	6	7
Color/math	11.7/2.1	1/8	8	14.3/3.6	6/1	1
ratio	5.6	.13	–	3.9	6	–

*Data reported in minutes of behavior.

**Contingent Response presented for this duration at randomly determined times throughout the session based on number of times I was completed in the previous schedule condition.

$I/C < O_i/O_c$ held true in the $\overline{RD}$ schedules. The exact I and C values employed were selected according to no set formula but were established so that the children could complete the contingency several times within a session and have a reasonable amount of time to work on each task. The children's schedule requirements were not identical because of differences in the operant levels of the behaviors that produced different O_i/O_c ratios. Each set of schedule terms was based on the average daily duration of the behaviors in the baseline prior to that particular schedule. The actual schedule terms for each of the children can be seen in Table 2.

Matched control (*MC*). The procedures of this condition were similar to those employed in the RD and $\overline{RD}$ conditions. The difference was that the contingent response was presented at randomly determined times, independent of the child's instrumental responding. However, it was available for the same amount of time and presented the same number of times as in the preceding schedule condition. It was expected that if schedule effectiveness was dependent upon a contingent relation between the responses, then any increased instrumental performance in the immediately preceding phase should decline under these conditions (Bernstein, 1974).

RESULTS AND DISCUSSION

The daily performance of the children on both tasks is presented in Figure 1, and their mean levels of responding across all conditions are depicted in Table 3. These data indicate that both children demonstrated an increase of coloring over their baseline levels when the RD schedule was in effect and little or no increase when the $\overline{RD}$ schedule was present. This suggests that math acted as a reinforcer for coloring when the conditions of response deprivation were present even though it was clearly shown in the baseline to be a lower-probability response. Therefore, consistent with the predictions of the Response Deprivation Hypothesis (Timberlake & Allison, 1974) and contrary to the Premack Principle (Premack, 1959, 1965, 1971), it does not appear necessary to have a higher-probability behavior serve as the contingent response to produce a reinforcement effect. This finding suggests that the presence of response deprivation alone in a schedule is sufficient to influence instrumental responding.

Although the increases of instrumental responding appear relatively weak by conventional clinical standards (Hersen & Barlow, 1976), the data must be evaluated relative to the schedule requirements. That is, the schedule requirements interact with the number of times a child

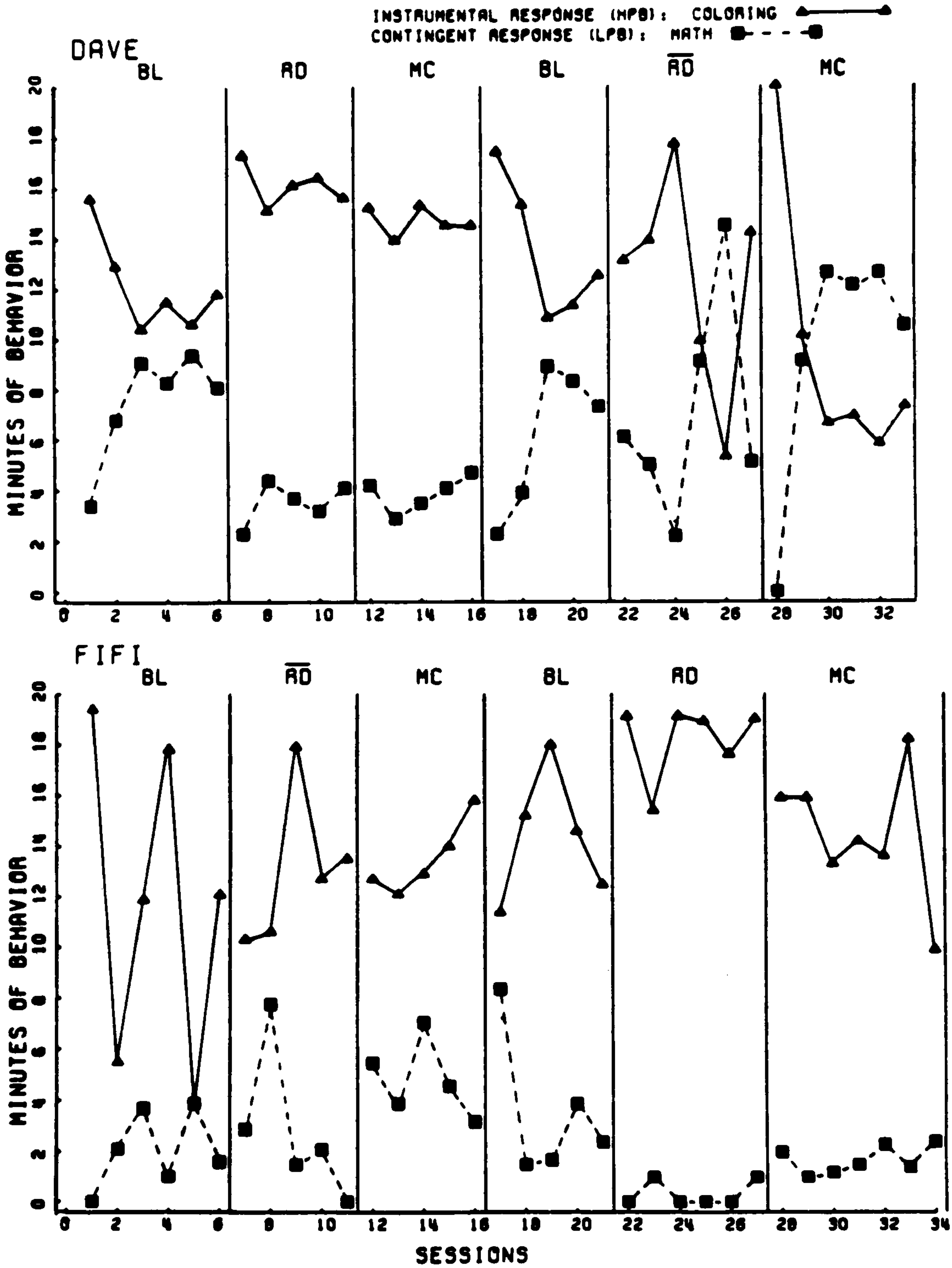

Fig. 1. Results of the schedule contingencies for Dave and Fifi. The top figure depicts the amount of instrumental and contingent responding, in minutes, shown by Dave in the Baseline (BL), Response Deprivation (RD), no Response Deprivation ($\overline{RD}$), and Matched-Control (MC) conditions. Coloring was the higher-probability behavior (HPB) and served as the instrumental response. The lower-probability behavior (LPB) was math and it served as the contingent response. The lower figure depicts the same information for Fifi.

Table 3
Daily Mean Duration of Responding Per Condition—Experiment I

Dave	*Color (I)*	*Math (C)*	*Fifi*	*Color (I)*	*Math (C)*
BL	*12.1	7.5	BL	11.7	2.1
RD	16.1	3.5	$\overline{RD}$	13	2.9
MC	14.7	1.4	MC	13.5	4.9
BL	13.5	6.1	BL	14.3	3.6
$\overline{RD}$	12.4	7	RD	18.2	.3
MC	9.4	9.5	MC	14.4	1.7

*Data in minutes.

could possibly complete both instrumental and contingent requirements within the 20-min session to limit the potential amount of instrumental responding. It should also be noted that because in this experiment the higher-probability behavior served as the instrumental response there was less opportunity to demonstrate a large increase in behavior than is the case when a lower-probability behavior is the instrumental response. Regardless, it does appear there were more reliable increases of behavior in RD relative to $\overline{RD}$ schedules.

A decrement of instrumental responding in the MC conditions was expected only following the RD conditions. However, the findings in these phases are somewhat problematical for only Fifi exhibited the expected reduction of previously increased instrumental behavior. The fact that Dave's increased coloring behavior was maintained in the MC condition may suggest that deprivation alone (without contingency) may be sufficient to achieve a reinforcement effect. It may be that true instrumental conditioning did not underlie the reinforcement effect; rather, the removal of the contingent response alone may have produced this result in the RD conditions (Bernstein & Ebbeson, 1978; Timberlake, 1979). However, certain methodological limitations in the use of the MC condition in the present study are relevant to this issue. First, it was not counterbalanced with respect to the RD conditions for positional or carry-over effects in this design. An MC condition before RD would be required for this purpose. Secondly, in the present use of the MC condition, some inadvertent pairings may have continued to occur on a random basis because the contingent response continued to be presented and removed in close temporal sequence to the instrumental response. This possibility is especially likely because the higher-probability behavior served as the instrumental response thereby increasing the chances for "superstitious" pairings. Finally, because the time course of the expected decremental effects of the MC condition is unknown, it is possible that a longer duration of this condition than was presently employed would be desirable, especially in view of any possible carry-over and/or superstitious reinforcement effects. All these factors suggest that the outcomes of the MC conditions, both supportive and nonsupportive of the Response Deprivation Hypothesis, should be viewed with caution as preliminary efforts.

In summary, the results of this experiment suggest the sufficiency of the state of response deprivation to produce reinforcement effects in an academic context, thereby systematically replicating basic laboratory research findings (Allison et al., 1979; Allison & Timberlake, 1974, 1975; Bernstein, 1974; Eisenberger et al., 1967; Heth & Warren, 1978; Timberlake, 1979; Timberlake & Allison, 1974; Timberlake & Wozny, 1979). However, because of the tentative nature of the effects of the MC conditions, it cannot be determined how much of the increases in the instrumental responding were due to the contingent relationship between the responses.

EXPERIMENT 2

Experiment 2 tested the prediction that a higher-probability contingent response would increase instrumental performance only when response deprivation was present in the schedule (Timberlake & Allison, 1974).

METHOD

Participants and Setting

Two children, Johnny and Sam, from the same classroom as Dave and Fifi, participated in this experiment. Like the children in Experiment 1, they were described by the teacher as average intellectually and presenting no behavior problem in the classroom. The setting was identical to that of Experiment 1.

Tasks and Materials

Math was again used as one task, but reading was substituted for coloring as the second task so the children could work on two academic tasks. Reading involved such responses as matching letters, writing letters, and reading books. With this exception, all materials used in Experiment 1 were also used in Experiment 2.

Definitions, Recording, and Reliability

The procedures and response definitions were identical with Experiment 1. On-task reading was defined as follows:

On-task reading: Child in seat at work table, gaze directed toward work materials obtained from reading tray and/or manipulating these materials.

There were 12 reliability checks on Johnny's data and 10 on Sam's. For both children there was at least one reliability check per experimental condition. Agreement on total daily duration of responding averaged 98% for both math and reading with a range of 93 to 100% for math and 91 to 100% for reading. On the interval-by-interval reliability analysis, math and reading averaged 98% agreement with ranges of 94 to 100% and 96 to 100%, respectively.

Design and Procedures

The same basic design as in Experiment 1 was used and again there were BL, RD, $\overline{\text{RD}}$, and MC conditions. However, one extra condition was added for each child. For Sam this condition was a reinstatement of the RD schedule and for Johnny a reinstatement of baseline (BL).

All procedures were conducted and schedules determined in the same fashion as Experiment 1, with the exception that the lower-probability behavior, reading, served as the instrumental response and the higher-probability behavior, math, as the contingent response. All information relevant to Experiment 2 is presented in Table 4.

RESULTS AND DISCUSSION

Figure 2 depicts the daily behavior of Johnny and Sam across all phases of the experiment and Table 5 contains their mean levels of responding. It can be readily observed that both children demonstrated reliable increases of instrumental responding in the RD conditions. For Sam this effect was replicated by reinstating the RD condition a second time. The changes in behavior were much larger than in Experiment 1 because the lower-probability behavior served as the instrumental response in this experiment. These findings are consistent with the predictions of both the Premack Principle and the Response Deprivation Hypothesis. However, neither child showed significant increases of instrumental responding in the $\overline{\text{RD}}$ schedules, suggesting that response deprivation was a necessary feature of effective reinforcement schedules where the higher-probability behavior serves as the contingent response. Furthermore, these data imply that probability differential alone is an insufficient condition for reinforcement because by itself this factor did not result in the reinforcement effect. This latter outcome replicates an earlier finding of Premack (1965).

Table 4
*Schedule Requirements—Experiment 2

Sam	*BL* O_i/O_c	$\overline{RD}$ *I/C*	*MC* *C***	*BL* O_i/O_c	*RD* *I/C*	*MC* *C***	*RD* *I/C*
# of sessions	5	8	8	6	6	5	6
read/math	2.9/15.4	.5/4	4	1.4/16.3	3/2	2	3/2
ratio	.19	.12	–	.09	1.5	–	1.5

Johnny	*BL* O_i/O_c	*RD* *I/C*	*MC* *C*	*BL* O_i/O_c	$\overline{RD}$ *I/C*	*MC* *C*	*BL* O_i/O_c
# of sessions	13	7	7	6	7	6	6
read/math	9.5/9.7	3/1	1	5/14.7	1/5	5	9.1/10.8
ratio	.98	3	–	.34	.2	–	.84

*Data reported in minutes of behavior.
**Contingent Response presented for this duration at randomly determined times throughout the session based on number of times I was completed in the previous schedule condition.

The above conclusions are more strongly supported by the data of Sam because he exhibited a clear probability differential between his reading and math behavior during baseline. The baseline data of Johnny, on the other hand, indicated no consistent probability differential between math and reading and therefore may not have provided a fair test of the Premack Principle. Specifically, according to the Premack Principle the reinforcement effect would be expected in neither the RD nor the $\overline{RD}$ condition if there was no probability differential between responses. However, this prediction was only supported in the $\overline{RD}$ condition because the reinforcement effect was apparent in the RD schedule, thereby also arguing against the idea that probability differential is a necessary condition for reinforcement. In sum, the increases in instrumental responding of both children can be better interpreted by the presence/absence of response deprivation in the schedules than from the existence of a probability differential between the responses.

The results of MC conditions following the RD schedules in this experiment again produced inconsistent findings. Sam's data gave evidence for the necessity of the contingent relationship between the instrumental and contingent responses because a return to baseline levels of instrumental responding was evident. However, Johnny's instrumental responding in the MC condition showed no decrease, a result which was observed in Experiment 1 with Dave and has also been found in other studies (Bernstein, 1974; Osborne, 1969). Due to these equivocal findings, more research is needed to determine

Table 5
Daily Mean Duration of Responding Per Condition—Experiment 2

Sam	*Read (I)*	*Math (C)*	*Johnny*	*Read (I)*	*Math (C)*
BL	*2.9	15.4	BL	9.5	9.7
$\overline{RD}$	4.6	10.1	RD	16.3	2.4
MC	8.1	7.8	MC	16.9	2.1
BL	1.4	16.3	BL	5	14.7
RD	11.5	6.1	$\overline{RD}$	8.6	10.9
MC	4	6.1	MC	8.7	10.7
RD	10.9	6	BL	9.1	10.8

*Data in minutes.

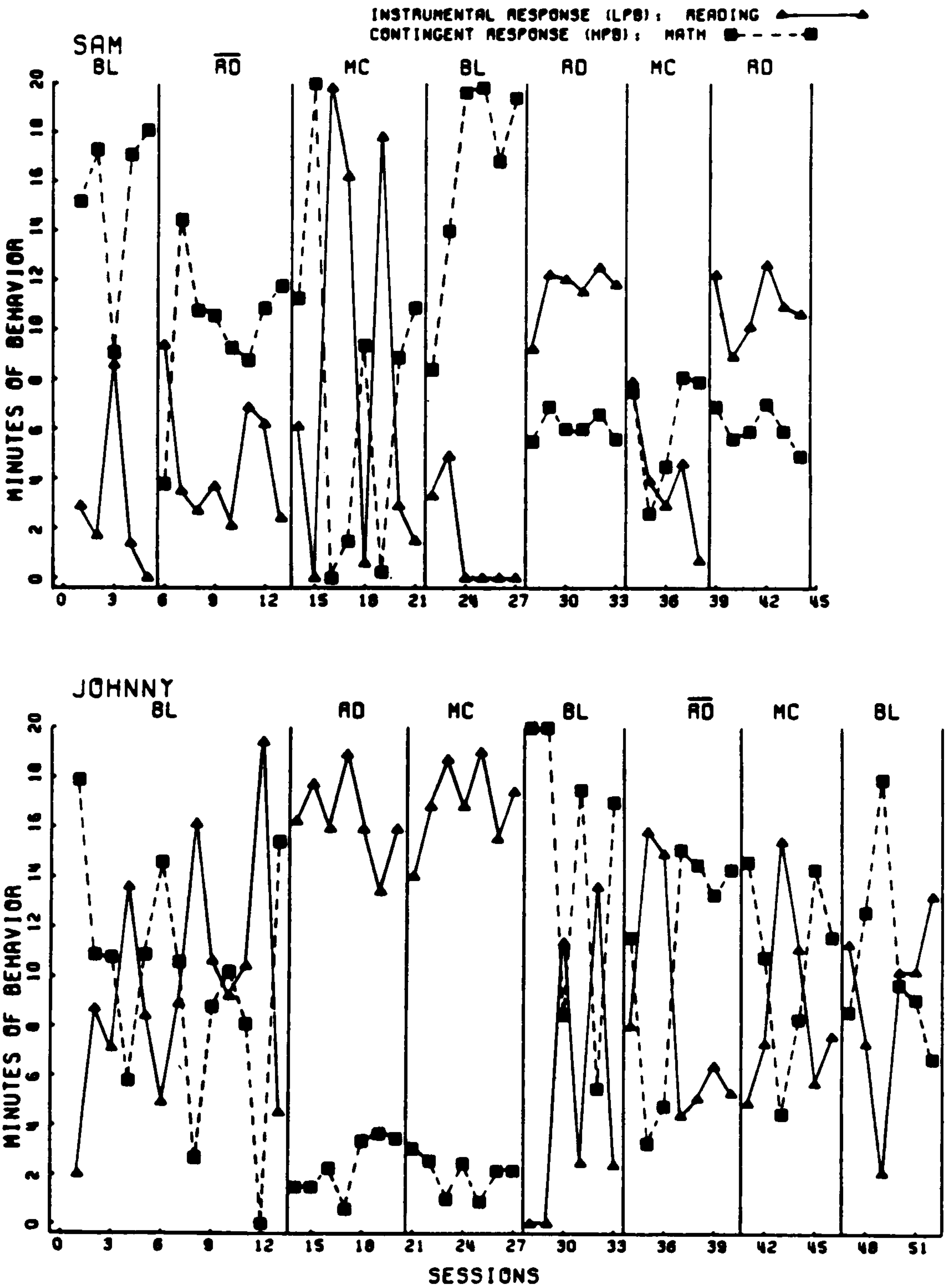

Fig. 2. Results of the schedule contingencies for Sam and Johnny. The top figure depicts the amount of instrumental and contingent responding, in minutes, shown by Sam in the Baseline (BL), Response Deprivation (RD), no Response Deprivation ($\overline{RD}$), and Matched-Control (MC) conditions. Reading was the lower-probability behavior (LPB) and served as the instrumental response while math was the higher-probability behavior (HPB) and served as the contingent response. The lower figure depicts the same information for Johnny.

both the contingent and noncontingent effects of instrumental schedules. Further investigation and discussion of this issue has been presented by Timberlake (1979).

GENERAL DISCUSSION

The results of both experiments clearly suggest that response deprivation was a sufficient (Experiment 1) and necessary (Experiment 2) condition for producing the reinforcement effect. This conclusion was supported by the finding that the reinforcement effect was evident only when response deprivation was present in the schedule, but not when it was absent, regardless of the probability differential between the responses. These results support the predictions of the Response Deprivation Hypothesis while being contrary to the notion of probability differential as the critical condition for reinforcement. It appeared that only when the schedule requirements interfered with the children's free-performance levels of responding did an increase of instrumental responding occur. The importance of the Response Deprivation Hypothesis in this regard is that it specifies a priori that point at which this interference (response deprivation) will be present in a schedule (i.e., $I/C > O_i/O_c$).

An issue that remains tentative is the contribution of the contingent relationship between the responses to the increases of instrumental performance. The results of the MC condition did not allow the conclusion that the children increased instrumental responding because it gained access to the contingent response. Rather, it may have been that this increase was a consequence of the unavailability of the contingent response for periods of time in the schedule conditions, perhaps merely reflecting substitution of the instrumental response as an alternative to contingent responding (Bernstein, 1974; Bernstein & Ebbeson, 1978). A response substitution mechanism such as this has been suggested by Rachlin and Burkhard (1978) to be an important variable underlying many reinforcement effects and deserves closer investigation. However, as noted by Timberlake (1979), although the noncontingent effects of a schedule may contribute to increases of instrumental responding, there exists ample evidence that important contributions are also made by its contingent aspects.

The importance of response deprivation in the present findings also suggests an alternative explanation of the results of previous laboratory (Premack, 1963; 1965; Schaeffer, Hanna, & Russo, 1966; Wasik, 1969) and applied studies (Ayllon & Azrin, 1968; Bateman, 1975; Roberts, 1969; Wasik, 1970) that were seen as due only to a probability differential between responses. In light of the present findings, these instances of apparent support for the Premack Principle may be conceptualized as special cases of the effects of responsive deprivation. That is, it now appears that the Premack Principle is successful only when it results in schedule requirements that produce the condition of response deprivation. Indeed, Premack was aware of the importance of this variable and suggested that researchers, "elevate this factor (relative suppression of the contingent response) from its obscure status as a hidden concomitant to that of a public operation where its consequences for theory can be examined" (Premack, 1965, p. 173). The present research may be viewed as following in this tradition.

It should be mentioned that this study differed procedurally from most of the laboratory studies of response deprivation (Allison & Timberlake, 1974, 1975; Timberlake & Allison, 1974) because a reciprocal contingency was not employed. In a reciprocal contingency, the subject must fulfill the instrumental requirement to gain access to the contingent response and then must complete the contingent requirement to regain the instrumental response. In other words, either the instrumental or contingent response is available to the subject during the contingency but never both at the same time. The procedure is employed to ensure that the subject meets with the experimenter-designated schedule requirements (Timberlake & Allison, 1974). However, Heth and Warren (1978) criticized the use of a reciprocal contingency on the grounds that it provided assessment of the instrumental response over a shorter time frame than during baseline thereby making it difficult to evaluate firmly the relative rates of responding between these conditions. To overcome this problem, the instrumental response was available for the entire session across all phases in this study. An examination of the actual rates of responding of the children determined that they were indeed meeting with the schedule requirements in both the RD and $\overline{RD}$ conditions. Importantly, the children's actual rates of behavior in the RD conditions continued to fulfill the response deprivation equation. Therefore, a reciprocal contingency was not required to have the children fulfill the requirements of the schedules.

The clinical significance of the present findings for applied researchers is that the Response Deprivation Hypothesis offers all the advantages of the Premack Principle (cf. Knapp, 1976, p. 134) for establishing reinforcement schedules plus several more. First, it increases the quantity of reinforcers available for use by specifying a larger pool of potential reinforcers than the Premack Principle. According to the Response Deprivation Hypothesis, any response can serve as a reinforcer for another response as long as its operant level is above zero. This hypothesis predicts that as long as the subject engages in a behavior, there is potential for using that behavior as a reinforcer, regardless of the probability differential, if any, relative to the desired instrumental response. Second, the Response Deprivation Hypothesis suggests that clinicians are not limited to traditional reinforcers which may be of dubious clinical value to the subject (e.g., free time, food) or to responses with appropriate probability differentials. Using this approach, the quality of reinforcers would be improved for responses that are of social, health, or educational benefit can be selected a priori to fit the specific needs of the subject. For example, as was the case in Experiment 2 of this study, academic behaviors could function as both the contingent and instrumental responses, thereby providing more opportunity for practice on these educationally important behaviors. A third advantage suggested by the nature of this hypothesis is that either behavior can serve as the instrumental or contingent response. Therefore, one set of baseline data could serve as the basis for establishing two different schedules, each using a different contingent response. These schedules could then be used at different times to alternately increase the performance of each behavior so that one behavior need not be continually suppressed at the expense of increasing another. An empirical demonstration of this use of the Response Deprivation Hypothesis in an applied setting would give tremendous support for its use as a clinical tool. Such demonstrations have already been made in laboratory studies of running and drinking in rats (Timberlake & Allison, 1974; Timberlake & Wozny, 1979). The fourth advantage of the Response Deprivation Hypothesis is that unlike the Premack Principle, which requires duration measures to determine the relative probabilities of the responses, any response measure (such as rate, frequency, or duration) can be used for assessment purposes (Timberlake & Allison, 1974). In fact, the same response measure need not be used to assess both behaviors. Different measures could be used as long as I is measured in the same units as O_I and C is the same units as O_C. This approach is a more flexible technique that can be applied using the most convenient response measure for a behavior in a particular situation.

Several points need be considered to use the Response Deprivation Hypothesis correctly as a guide for establishing reinforcement schedules. The first is that an accurate assessment of the operant levels of both behaviors must be accomplished to determine schedule requirements that produce response deprivation. Timberlake and Allison (1974) suggested that a paired-operant baseline, where both responses are freely available at the same time, is the best method of obtaining this assessment. The typical method of assessing only instrumental responding (Knapp, 1976) must therefore be expanded to include assessment of the contingent response.

Second, to date, the hypothesis has primarily been tested only in situations where the subject did not have ready access to alternative responses which may act as substitutes for the desired instrumental response. Therefore, its clinical application is limited to situations where there are only two clearly defined responses. Although Bernstein (1974) has provided initial support in this regard, further support for the Response Deprivation Hypothesis within the context of a multiple response setting is required before its application can extend beyond a two response situation.

Finally, any schedule requirements that produce response deprivation should produce the reinforcement effect. However, if the schedule requirements are so large that the subject cannot fulfill them or cannot form the contingent relationship between the responses, an increase of instrumental responding may not appear. Thus, unless instructions or cues are used to communicate the schedule requirements and the relationship between the responses (Bernstein, 1974), they must be small enough so the contingency can be completed several times within a session to make it more likely the subject's behavior will come in contact with the schedule. A practical caution regarding this suggestion is that schedule requirements cannot be so small as to prohibit appropriate responding. For example, access to complex math problems for only 30 sec may interfere with the student being able to complete a problem within that time frame.

In conclusion, the preliminary evidence presented here suggests that the Response Deprivation Hypothesis may offer an accurate explanation of reinforcement effects in single response, instrumental schedules using academic responses. More importantly for applied researchers, it appears this hypothesis has some important implications for the control of socially important behaviors in that it seems to have further advantages to its use as a tool for establishing reinforcement schedules than any previous approach. More research is needed of both an applied and experimental/theoretical nature, however, to determine the applicability and effectiveness of this hypothesis for use in applied settings.

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