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Choice, Commitment and Time Horizon

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Abstract

Timberlake, Gawley, and Lucas (1986) found that rats were unable to anticipate future resources (food) that were delayed by 16 minutes or more. The 15 minute period during which the rats were able to anticipate food which would be available in the future is called the time horizon. The present experiment sought an explanation of the fact that the animals in the Timberlake et al (1986) study could not anticipate free food beyond 15 minutes and to also examine whether the time horizon of rats can be lengthened. In most sessions, a single response bar (left or right) was presented at the start of the session. One bar was associated with 30 minutes of a progressive ratio schedule. The other bar was associated with the same progressive ratio schedule, followed by 5 minutes of free food. The bar presented alternated randomly from day to day. Once every 5 sessions, both bars were presented at the start of the session, and the animals chose between them. None of the animals consistently chose the PR and FF schedule suggesting that in this contingency, rats cannot "anticipate" over a 30 minute gap.

Key words: rats, time horizon, progressive ratio schedule, free food, commitment, anticipation.

Introduction

Efficient foraging behaviour requires that an animal be able to integrate information about future resources into its present performance. If future resources are temporally distant, small, uncertain, and/or difficult to obtain, it is probably more efficient for an animal to continue responding to resources available at the present. If future sources of reinforcement are temporally close, large, certain, and/or easy to obtain, it may be more efficient for an animal to cease responding in the present, thus conserving energy while it waits for the arrival of future resources. (Lyn & Dougan, 1991, Shimp, 1982)

Research results have shown that animals, when given a choice between a small immediate reward and a large delayed one, tend to pick the small immediate one because of the discounting effect of the temporal delay (Rachlin & Green, 1972; Fantino, 1977; Timberlake, 1984). Thus, it seems temporal delay is an important factor to consider in experiments or situations that require animals to integrate input over time on how to determine the allocation of resources among alternatives. Animals will respond in a present situation as though unaffected by future resources, if the future resources are too distant in time.

Timberlake (1984) put rats on a progressive ratio (PR) schedule for an hour each session and then presented them with free food at various times ranging between 1 and 23 hours after the experimental session. A progressive ratio schedule is one in which the response requirement increments by one after every reinforcer. For example, the first reinforcer would require one response, the

second reinforcer would require two responses, the third would require three responses and so on. As can be seen, the progressive ratio schedule increases in difficulty for each successive pellet. Theoretically, an animal could work (bar press extensively) for the entire PR schedule, work up to a point and then quit, or not work at all. If the animal is integrating information about the future free food then it should quit responding in the PR schedule quickly and wait for the free food.

Timberlake (1984) assessed the time period during which access to future food would affect current responding. He wanted to see at what period of time the rats would cease to integrate information about the future free food into their performance during the progressive ratio schedule. Stated another way, he wanted to know when the animals would cease to anticipate the free food. Animals would show they were anticipating if they suppressed responding during the PR schedule to wait for the future free food. His results indicated that future food delayed by an hour or more had no effect on the rats performance during the PR schedule. The rats performed on the difficult PR schedule as if no future food would be forthcoming. They did not suppress responding.

Timberlake

(1984) therefore concluded that rats could not anticipate food over such a long delay.

In a subsequent study done to determine the interval during which access to future food would affect current responding, Timberlake, Gawley, and Lucas (1987) found that future food delayed by 16 minutes or more had no effect on current responding.

The 15 minutes during which the rats are able to integrate information about future resources into their current performance is known as the rat's "time horizon". Hence, a time horizon may be defined as a period of time beyond which future resources have no effect on present responding (Lyn & Dougan, 1991). In the Timberlake, et al (1987) experiment, future food was presented on a delayed continuous reinforcement (CRF) schedule. A CRF schedule is one where every response is followed by a reinforcer. Thus the immediate PR schedule was a small and difficult reward, while the delayed CRF schedule was large and easy access reward. They found that the rats would suppress responding on the PR schedule when the delay between the two rewards was 15 minutes or less, but when the delay was 16 minutes or more the animals began to respond on the PR schedule as if no future food was forthcoming.

There appears to be very little research done that looks at time horizons in animals. Hodos (1967) suggested that chimpanzees tend to minimize reinforcement cost but did not determine at what time they began to do this. Timberlake (1984) suggested that it may be approximately 15 minutes.

Timberlake et al (1987) interpreted the short time horizons in rats as a performance effect. They assumed that the rats were able to learn about future free food, but performed as if no such free food existed; in other words they did not fail to learn, they failed to perform. Such an interpretation is consistent with temporal discounting functions (e.g., Rachlin, & Green, 1972, & Rachlin, Castrogiovanni, & Cross, 1987) which discount the value of future resources in relation to the value of immediately available resources.

There is an alternative explanation to this performance-based interpretation. It is possible that the short time horizons observed in Timberlake's studies (1984, 1987) occurred because the rats failed to learn about the future resources and not because they discounted the future food.

One way to determine whether this short time horizon is due to a learning deficit is to facilitate the learning process by making learning as easy as possible. Mazur & Logue (1978) accomplished this by using a temporal fading procedure to increase the interval over which pigeons would demonstrate self-control. This temporal fading procedure originated by Ferster (1953), is a procedure where gradual changes are employed along some stimulus dimension. In the temporal fading procedure used by Mazur and Logue (1978), pigeons initially chose between two different schedules of reinforcement, each with an identical delay in reinforcement delivery. The delay to one of the sources of reinforcement was slowly reduced (over a period of 11,000 trials), until the birds were choosing between sources of reinforcement with widely unequal delays. Pigeons exposed to this temporal fading procedure demonstrated "self-

control" over much longer time intervals than pigeons not exposed to the fading procedure. Self-control, or impulse control, takes place in choice situations where there is a small immediate reinforcer and a large delayed reinforcer (Ainslie, 1975). An animal exerts self-control if it takes the larger delayed reinforcer over the smaller immediate one. Mazur and Logue (1978) concluded that the pigeons conditioned using the temporal fading procedure learned to choose a large delayed reinforcement over a small immediate one when the delay was gradually decreased. Thus the temporal fading procedure apparently facilitated the ability of the pigeons to learn about the delayed reinforcement.

Lyn and Dougan (1991) explored whether the time horizon that Timberlake, et al (1987), found could be extended using a modified version of the Mazur and Logue temporal fading procedure in Timberlake's time horizon paradigm. The experiment allowed the rats immediate access to food on a PR schedule and a delayed access in a CRF schedule. Food in a PR schedule is a small amount and difficult to obtain whereas the food in the CRF schedule is a large amount and is easy to obtain. In the first group of three groups, the CRF schedule began 5 seconds after the PR schedule and the delay incremented by 15% each successive day. For the second group, the CRF began 5 seconds after the PR schedule but it incremented by 30 % for each successive day. Increment means the delay is slowly increased by adding a fixed percentage to the previous delay. This is similar to the Mazur and Logue (1978) temporal fading procedure only instead of fading, Lyn and Dougan (1991) were shaping, thus they called it a temporal shaping procedure. They gradually

increased the delay to get the animal to "anticipate" over longer intervals. This gradual increase in the delay can be seen as shaping the animal by successive approximations. As in Timberlake's 1984 experiment the animals could work for food on the PR schedule, they could wait for the CRF schedule, or they could do a combination of both. The third group, the control group, was subjected to the same conditions as the other two groups differing only in that the temporal shaping procedure was not used. Instead, the CRF schedule began 30 minutes after the PR schedule. In the two groups exposed to the temporal shaping procedure, the delay of the CRF schedule was slowly increased until the delay was equal to the 30 minute delay the control group was subjected to. The number of responses the rats made to the CRF and PR schedules was measured as a function of the delay in the CRF schedule. Lyn and Dougan's (1991) results indicate that rats which are exposed to this temporal shaping procedure may have longer time horizons than rats not exposed to such a procedure. Overall response rates on the PR schedule were lower in the temporal shaping groups than in the control group but not significantly so. This suggests that it may be possible to lengthen the 15 minute time horizon that Timberlake et al found (1986) , but, because their results were not statistically significant, no firm conclusions can be drawn.

The present experiment attempted to supply evidence that the Timberlake et al (1987) time horizon in rats can be lengthened using another approach. A choice and commitment procedure was used. The rats were placed on five-day cycle schedules. For four days they were presented with either a 30 minute PR schedule or or a 30

minute PR schedule followed by 5 minutes of free food (FF). The 30 minute PR schedule exceeds the Timberlake et al (1987) 15 minute time horizon. On the fifth day the rats were presented both schedules and were required to make a choice. When a rat made its choice, the bar with the other schedule retracted, leaving the rat committed to its choice.

If the animals integrate information about the future free food, they should be able to discriminate between the two schedules. Successful discrimination in this study would indicate that the time horizon can be extended beyond 15 minutes as the delay between the PR schedule and the FF is 30 minutes. If the animals discriminate between the two schedules but fail to suppress responding during the PR with FF schedule, this would suggest that they learned about future free food but are unable to wait for it. This can be interpreted as a performance effect. Though discrimination is being used to test whether the animals are anticipating, early researchers were reluctant to use it to explain behaviours. For example, Stubbs (1968) cautioned the use of discrimination in explaining behaviours because other variables such as frequency and amount of reinforcement may interact to produce invalid results. The present study does not have this problem because all animals were subjected to the same conditions and the schedules were the same with the only difference being the 5 minutes of free food.

The choice and commitment procedure should force the animals to discriminate between the alternatives. Ferster (1953) implied that the way in which a delay of reinforcement is implemented is more critical than the delay of reinforcement itself.

This suggestion that the method plays a crucial role in the results is supported by the results of Mazur and Logue (1978) who found that gradual delay produces "self-control" in pigeons. This is in keeping with the learning deficit hypothesis. Thus the present experimental design, like the temporal fading and the temporal shaping procedure should help the animals learn about the future free food. Another reason for using a choice and commitment procedure is that it appears to increase "self-control" in animals and enhance learning. Research (Rachlin & Green, 1972, Ainslie, 1974) has shown that animals forced to make an irreversible commitment to a large delayed reward increase self-control, or if they made a high number of initial larger reinforcer choices, they tended to maintain those choices (Logue & Pena- Correal, 1984). Also, Zeiler and N. Solano (1982) suggested that pigeons can discriminate their own behaviour, therefore if they are discriminating, then they are showing that they know about their own behaviour and have learned about the delay. Thus their research supports my use of a discrimination procedure to determine whether the animals are learning about the future free food.

Method

Subjects

The subjects were five naive Long Evans rats obtained from the breeding colony at Illinois Wesleyan University. Each rat was housed individually with water provided at all times except during the experimental sessions. They were fed rat chow (enough to maintain

their weight) one hour after each session (see procedure for detailed explanation).

Apparatus

The apparatus which was used is a standard operant conditioning unit for rats (BRS-LVE RTC-020). The front wall has two retractable bars, six cue lights, a feeder, a ventilator, and a house light. A hand switch was used to start each session. The unit was enclosed in a sound attenuating wooden box. Schedule control and data collection were maintained by an IBM XT clone running MED-PC software, and using a MED Associates interface.

Procedure

All rats were food deprived to 80 percent of their free feeding body weight. They were then shaped to bar press on right and left levers using food as reinforcement. Reinforcers were 45 milligram Noyes improved formula A rodent pellets. When all rats were responding equally to both bars, the experiment was begun. The experiment was conducted daily between 12 am and 4 pm in a dark, temperature controlled room (average temperature 85 degrees).

Rats were exposed to schedules in five-day cycles. The first four days were "run" days and the fifth was the "test" day. On run days the animals were exposed to either the PR schedule or the PR with FF schedule. The cycles were repeated 10 times for a total of 50 sessions or 50 days.

On the run days, by random determination, either the left or the right bar was presented. The randomness prevented the animal from anticipating which schedule would be in effect. One bar was

associated with a 30 minute PR schedule. On the PR schedule, the response requirement incremented by one response after every reinforcer. The other bar was associated with the same PR schedule but was followed by 5 minutes of FF. Free food was food the animal did not have to bar press for, instead, the feeder emitted one hundred pellets during the 5 minute period. All bars were retracted while the free food was available. The bar associated with each schedule, was counterbalanced across animals to control for side preferences. Thus, some animals had the PR schedule on the left bar (the bar farthest from the door) while others had it on the right bar (the bar closest to the door).

A session ran like this: subject 1 had the PR schedule on the left bar. At the start of the session the left bar came out and the red light above it was illuminated. For 30 minutes the rat was subjected to the PR schedule and when time was up, the red light went off and the bar was retracted signalling the end of the session. For that same subject on the PR with FF schedule, the right bar came out, and the green light above it lit up. The rat had 30 minutes of the PR schedule which was then followed immediately by 5 minutes of free food. During the free food delivery all bars were retracted and only the house light was on. After the 5 minutes of free food, the house light would go out signalling the end of the session.

In the test sessions both bars were out at the same time. Thus both schedules were on concurrently. As mentioned before, the schedules were on a particular bar depending on the counterbalance across animals. Thus, using my previous example, subject 1 had the PR schedule on the left bar and the PR with FF schedule on the right

bar. While both bars out, their respective lights were on. The animals then chose one bar and when that choice was made, the other bar automatically retracted, its light extinguished, and the subject was committed to the bar it had selected. If for instance, subject 1 chose, the PR schedule bar, then it would get the 30 minutes of PR schedule but no free food. If it chose the PR with FF bar, then it would get 5 minutes of free food after the 30 minutes of PR schedule.

The animals did not maintain the desired body weight with the food earned in the experimental sessions, therefore additional food was provided one hour after the experimental session. I fed them after one hour because Timberlake (1984) showed that rats discounted food delayed by an hour or more, therefore this additional food should have had no consequence on their behaviour in the experimental sessions.

Subject 1

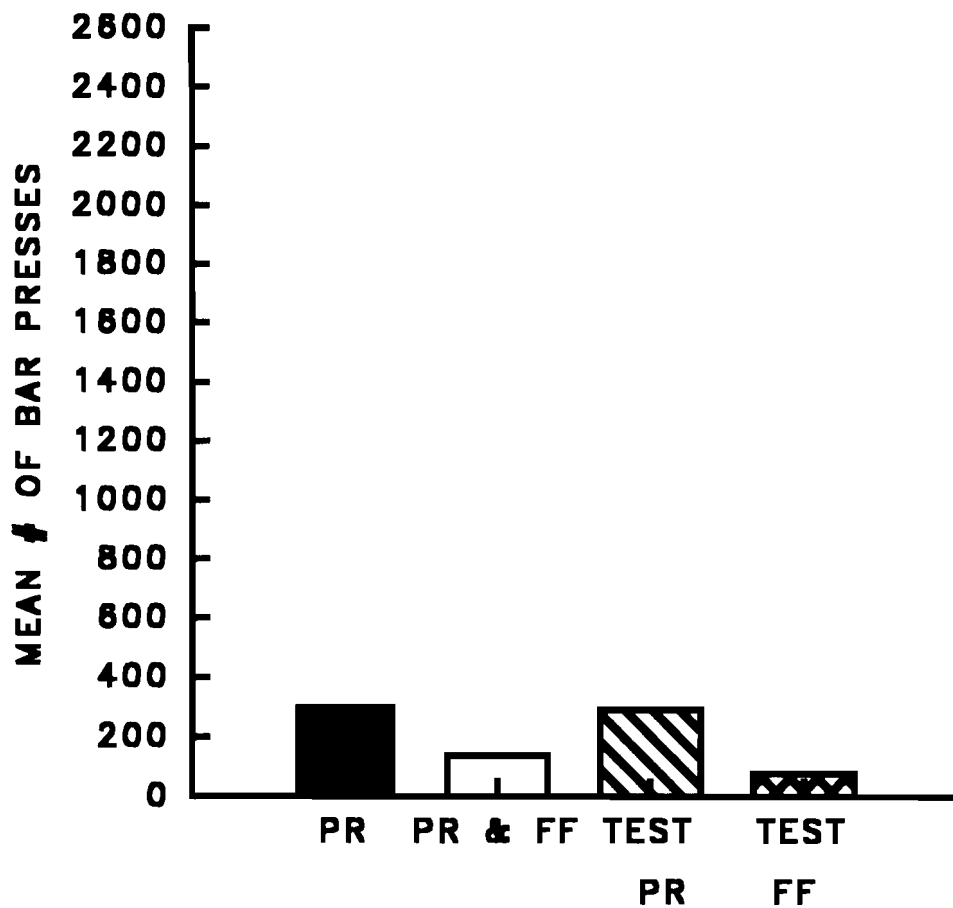


Figure 1. Comparison of the mean number of bar presses for subject 1 during the run and test days for the two schedules.

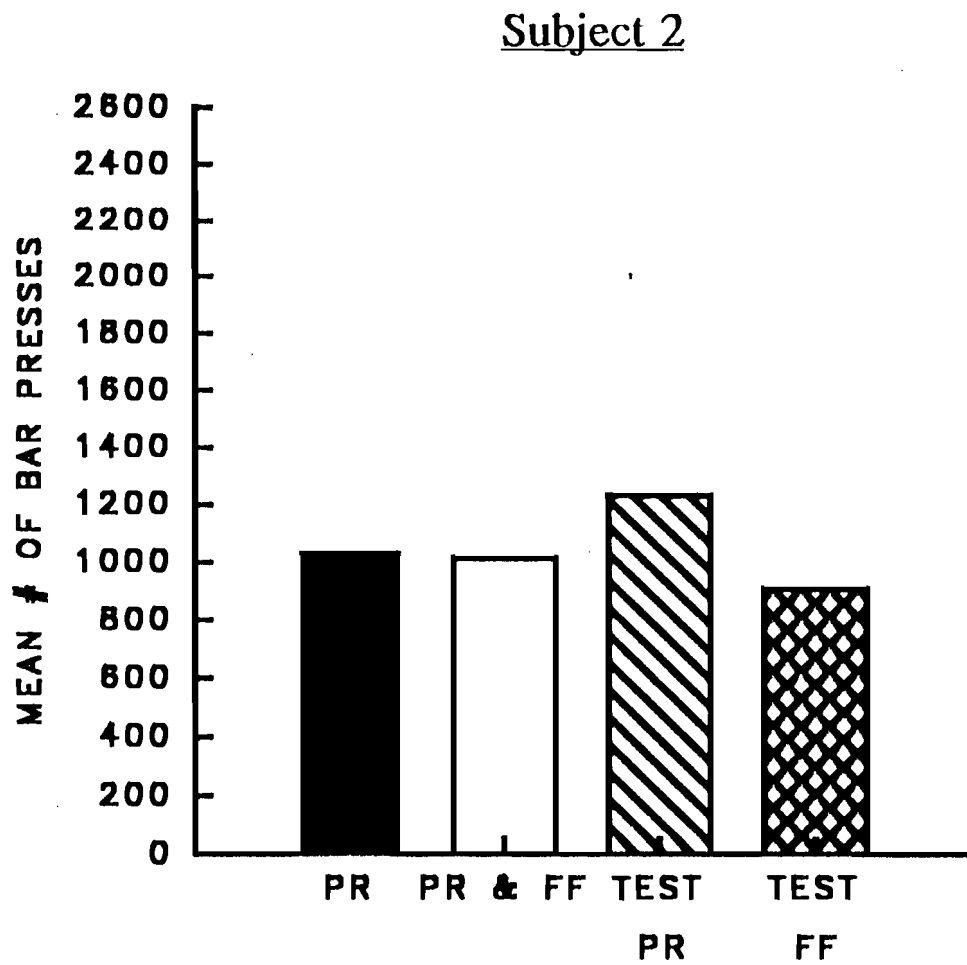


Figure 2. Comparison of the mean number of bar presses for subject 2 during the run and test days for the two schedules.

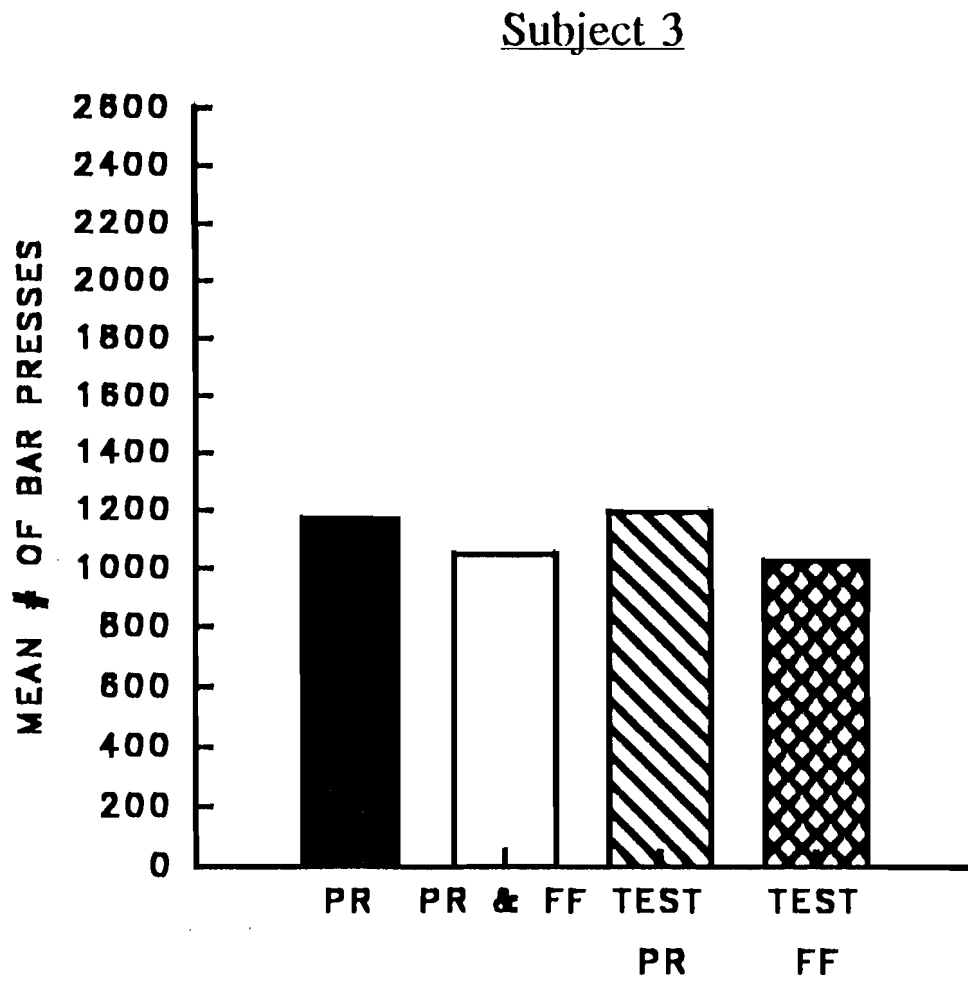


Figure 3. Comparison of the mean number of bar presses for subject 3 during the run and test days for the two schedules.

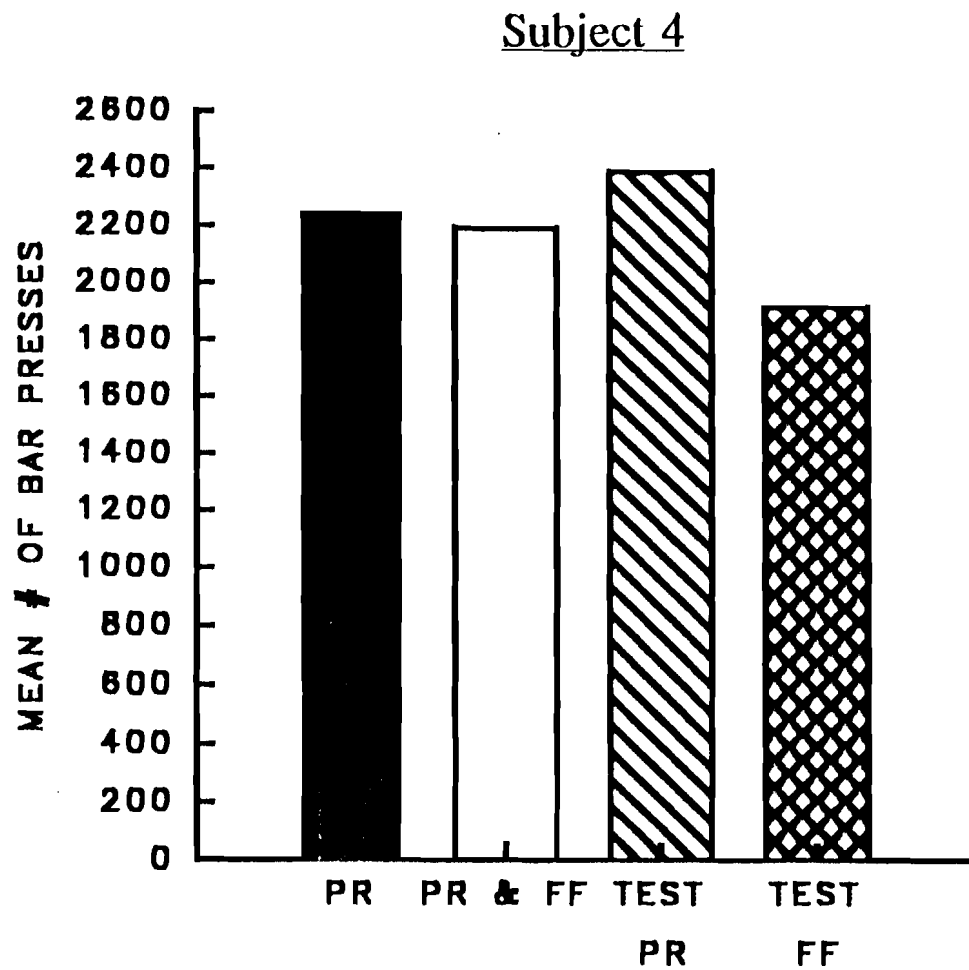


Figure 4. Comparison of the mean number of bar presses for subject 4 during the run and test days for the two schedules.

Subject 5

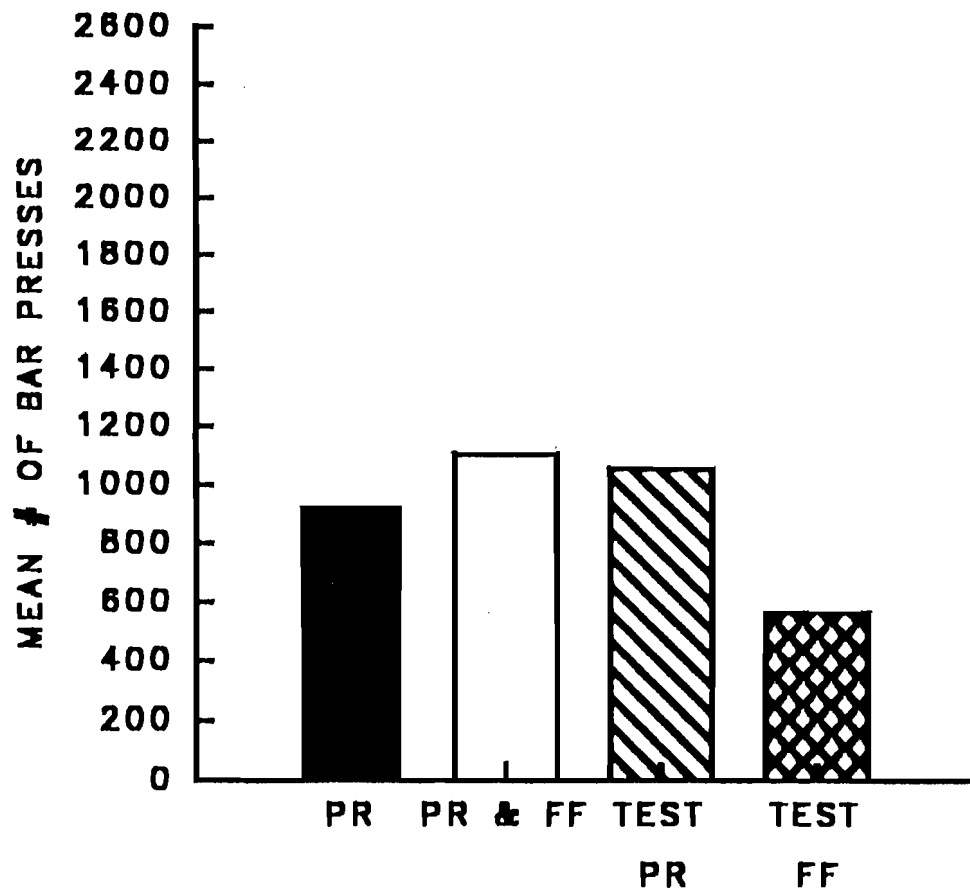
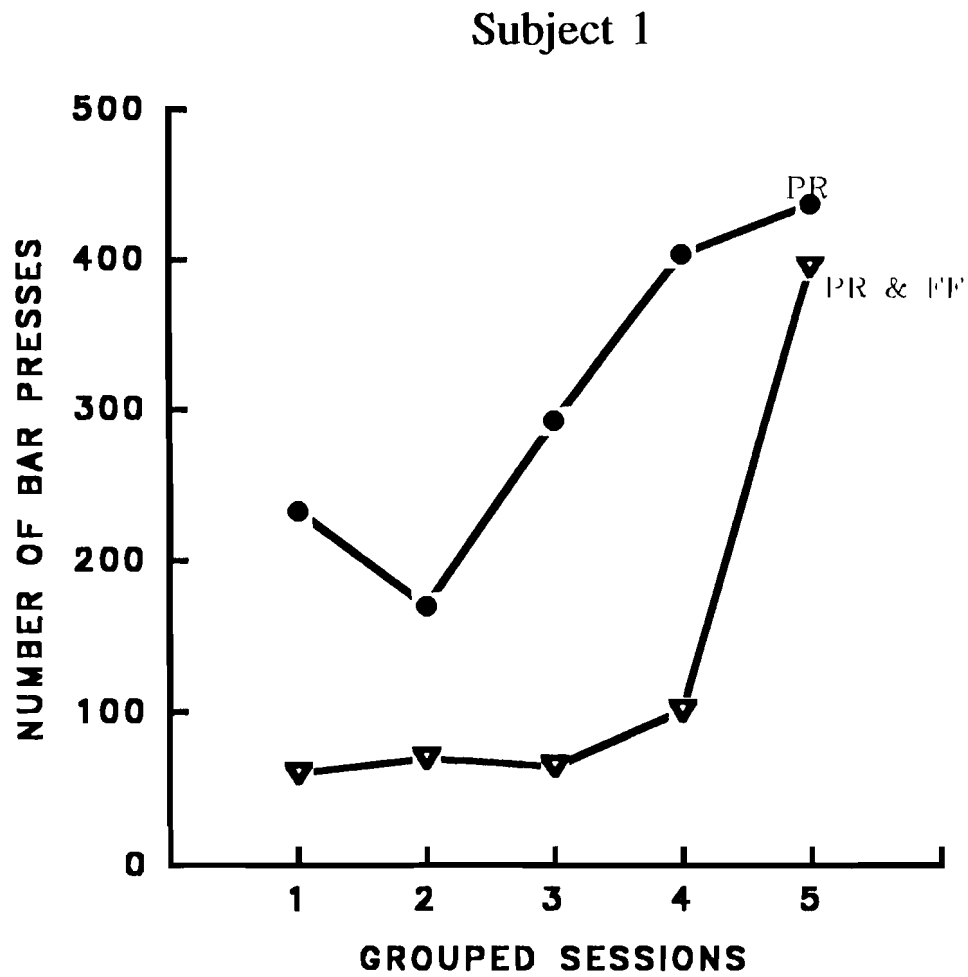
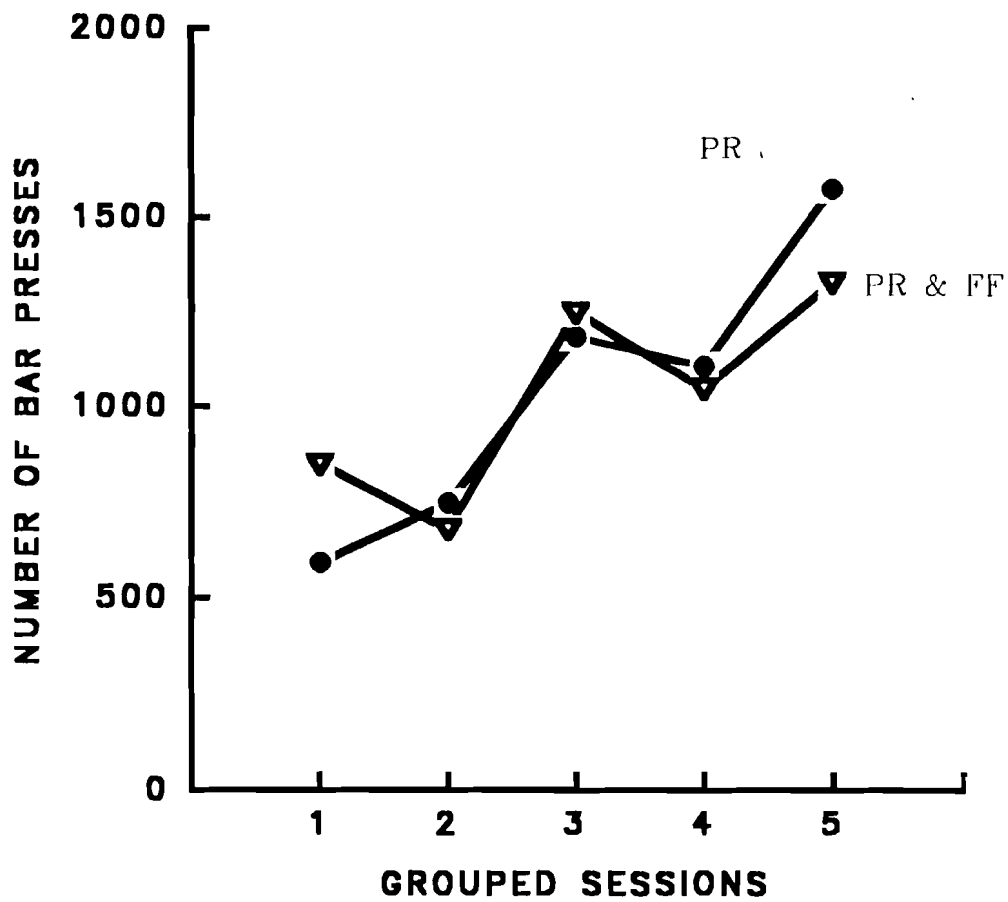


Figure 5. Comparison of the mean number of bar presses for subject 5 during the run and test days for the two schedules.

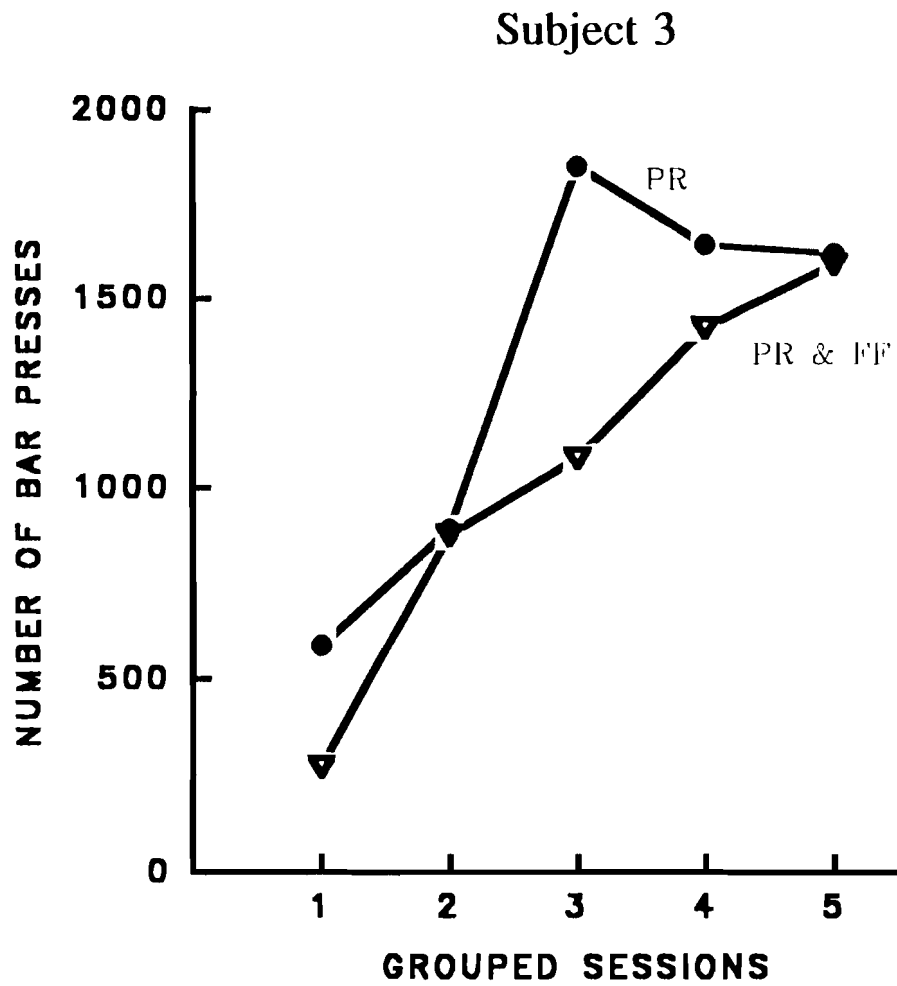


Graph 1. The number of bar presses on the PR & FF and PR schedules during the run days. The sessions are grouped in four day blocks.

Subject 2

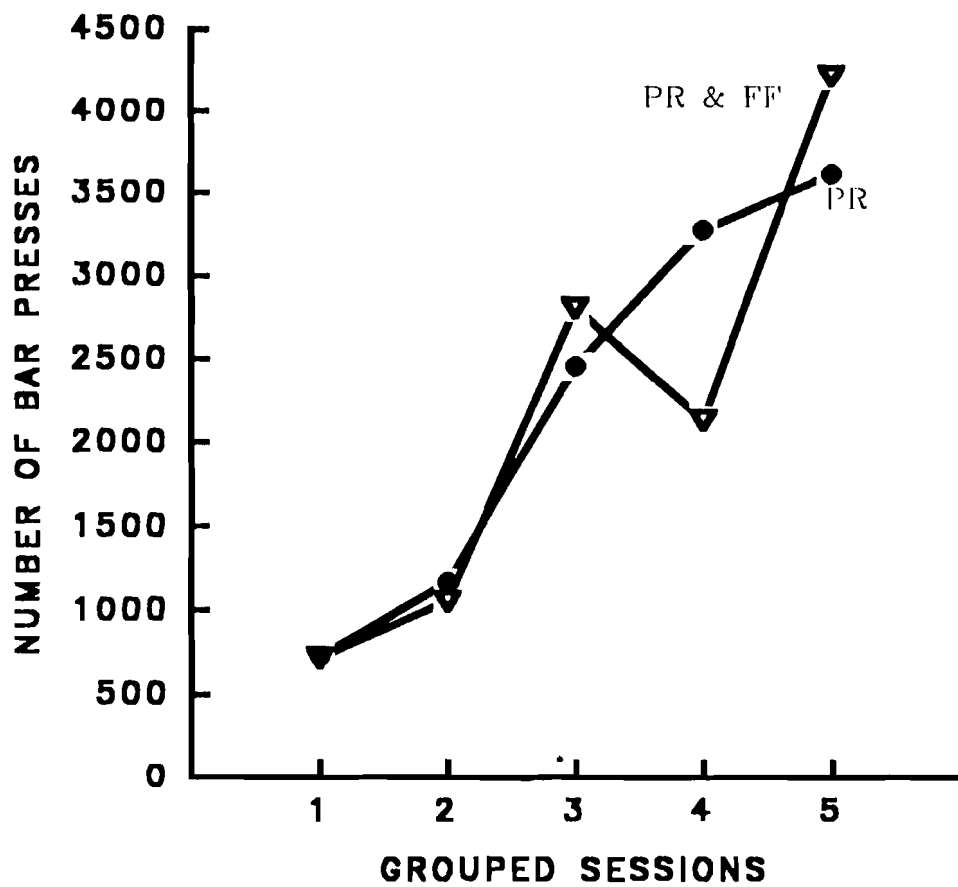


Graph 2. The number of bar presses on the PR & FF and PR schedules during the run days. The sessions are grouped in four day blocks.

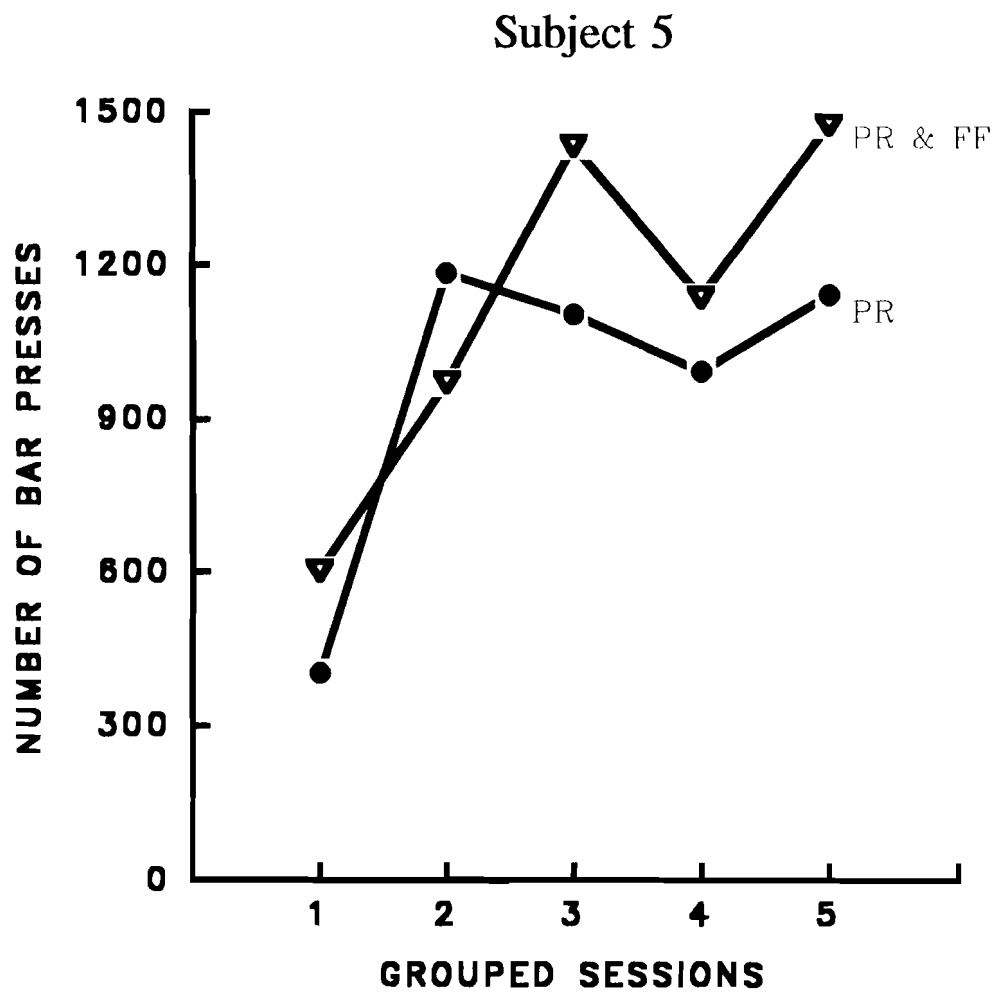


Graph 3. The number of bar presses on the PR & FF and PR schedules during the run days. The sessions are grouped in four day blocks.

Subject 4



Graph 4. The number of bar presses on the PR & FF and PR schedules during the run days. The sessions are grouped in four day blocks.



Graph 5. The number of bar presses on the PR & FF and PR schedules during the run days. The sessions are grouped in four day blocks.

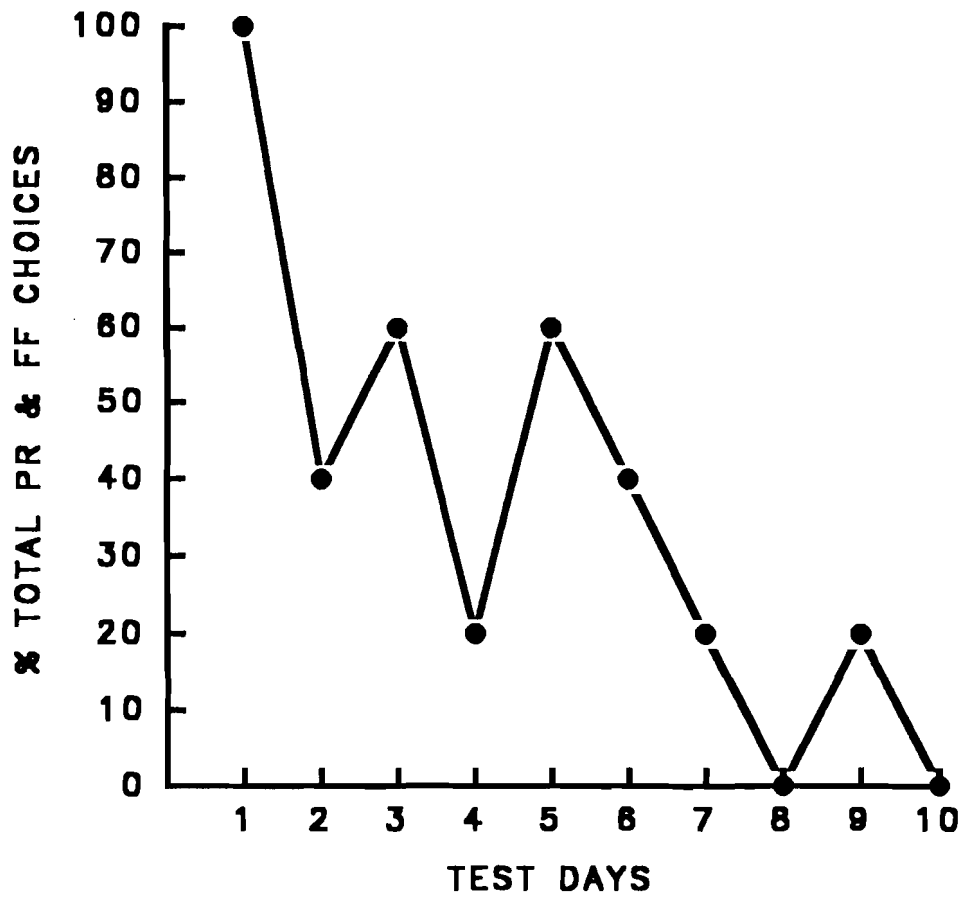
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Table 1

	1	2	3	4	5
Subject 1	PR&FF (86)	PR (189)	PR&FF (34)	PR (417)	PR&FF (43)
Subject 2	PR&FF (752)	PR&FF (594)	PR&FF (638)	PR&FF (1085)	PR&FF (1484)
Subject 3	PR&FF (64)	PR&FF (740)	PR (776)	PR (946)	PR&FF (1422)
Subject 4	PR&FF (1641)	PR (1168)	PR&FF (1334)	PR (1334)	PR (2345)
Subject 5	PR&FF (564)	PR (804)	PR (992)	PR (1193)	PR (1273)
%total PR&FF	100	40	60	20	60

6	7	8	9	10	% PR&FF
PR (273)	PR (311)	PR (303)	PR&FF (139)	PR (250)	40
PR (1200)	PR (1615)	PR (991)	PR (1325)	PR (1039)	50
PR&FF (1475)	PR&FF (1436)	PR (1289)	PR (4279)	PR (1080)	50
PR&FF (2767)	PR (3240)	PR (2488)	PR (4279)	PR (1846)	30
PR (1091)	PR (861)	PR (835)	PR (1327)	PR (1127)	10
40	20	0	20	0	

Table 1. Subjects' choices during the 10 test days. Number of responses are in parentheses. The horizontal percentages indicate the percent of all the subjects who chose the PR and FF schedule for each day. The vertical percentages indicate the percent total PR and FF schedule choices for each subject.

Figure 6



The percentages for the subjects that chose the PR & FF schedule during each test day.

Results

As can be seen from table one, during the test days none of the animals consistently chose the PR and FF schedule. Indeed, in the last two test sessions, only one animal, subject 1, chose the PR and FF schedule. In the initial sessions, the animals tended to choose the PR and FF schedule but in the later sessions their choice switched over to the PR schedule.

The bar charts (Fig. 1 -5) present the results for each of the five subjects. The mean rate of responding is graphed for the two schedules during the run and the test days. There was no significant difference in the response rate for the PR schedule and the PR and FF schedule across subjects on the run days ($t=.713$, $p < .01$). As can be seen from the figures, the average rate of responding on the PR and FF schedule was not much lower than the average rate of responding on the PR schedule. In fact, subject 5 tended to respond more during the PR and FF schedule.

For purposes of comparison, the data collected for each subject during the run days were grouped in four day blocks and graphed. Sessions were grouped because performance in the later sessions should provide a better indication of performance than earlier sessions when the animal had less experience with the bars. Results are inconsistent: In the last two session blocks, three of the five animals have a lower rate of responding during the PR & FF schedule, while the other two subjects have a higher rate of responding on the same schedule.

There was a significant difference in the response rates on the PR schedule and the PR and FF schedule across subjects during the

test days ($t=5.11$, $p=.005$). Whenever the animals chose the PR schedule during the test days they tended to respond more than they did when they chose the PR and FF schedule (figs. 1-5).

Conclusion

The present data suggest that rats exposed to a choice and commitment procedure, are unable to "anticipate" over a 30 minute gap. This conclusion is based on the fact that none of the animals consistently chose the 30 minute PR and FF schedule. Though two of the animals chose the PR and FF schedule 50 percent of the time, this was not enough to conclude anticipation and more importantly they did not choose consistently (Table 1).

Subjects chose the PR and FF schedule more often in the first five test days than they did in the last five test days (fig. 6). This is a very interesting and unusual finding especially since it is counter - intuitive to my hypothesis- that they would consistently chose the PR and FF schedule. Instead of choosing consistently, they started out choosing the PR and FF schedule then later on switched to the PR schedule. These results may be explained using Behavioral contrast (see Williams, 1983 for more on contrast). What could be happening, and this is speculative, is that initially, the PR schedules are valued the same and the FF at the end of the PR and FF schedule was the decisive factor in choice. But, as the animals became more exposed to the schedules, they tended to devalue the PR in the PR and FF schedule in relation to the FF. Thus, the PR by itself now had a greater value than the PR in the PR and PR and FF schedule. Hence, in later choice conditions (test days), the PRs of the two-schedules now

have unequal values. The PR schedule by itself has a greater value than the PR schedule in the PR and FF schedule. The animals then chose the PR schedule because of its immediate greater value. Again, this is only a speculation, other explanations may exist.

On the the run days there was no significant difference in the rate of responding during the two schedules. However on the test days, the results showed that when the rats chose the PR and FF schedule, they had a significantly lower response rate than when they chose the PR schedule. This significance in response rates can be attributed to the fact that we had not yet achieved steady state in the rate of responding. Graphs 1 - 5 indicate that the rate of responding for animals was increasing for all animals thus asymptote had not been attained. This failure to reach asymptote is a shortcoming of the present experiment. Future study should be carried out until steady rates of responding is achieved in all animals.

The implications of the present study are unclear. The results did not support either the performance or the learning deficit hypotheses. Some of the animals appeared to be suppressing, but not enough to draw any firm conclusion. If they are really suppressing, then it would suggest a performance effect, but, as these was no significance during the run days, there is an uncertainty as to if they are really suppressing.

The present study and its results once again raise the issue of the relationship between instrumental conditioning and foraging. I used operant conditioning to test for the time horizon in rats. This time horizon is important in the foraging behaviour of rats and as

such is a major concern of behavioral ecology. Hence, it is appropriate to question whether there is any ecological validity to my using operant conditioning to find the time horizon in rats. Do bars and reinforcement schedules really simulate depleting patches? I believe the answer to this questions is yes.

There appears to be a strong link between optimal foraging as described in the literature and operant conditioning. Lea points out three major points to this argument:

1. Some of the behavioral phenomena that have been reported in the ecological literature on foraging seem analogous to well-known conditioning effects.
- 2 It turns out the foraging-like phenomena can be produced in the laboratory, when the responses involved are not the species' characteristic "instinctive" foraging patterns but conditioned operants.
- 3 It is therefore possible to argue that the behavioral patterns producing optimal, or near optimal, foraging whether in the laboratory or in the wild may be produced by operant conditioning: in other words, operant conditioning is the mechanism of optimal foraging. But if that is so, it is also quite likely that the selective advantage of foraging optimally explains the form of the principles of operant conditioning. (Commons, Herrnstein, & Rachlin, 1982, p. 170).

Lea went on to suggest that "if conditioning principles have evolved under the pressure of the need to forage optimally, that should give the comfort of some ecological validity to those who investigate them; it refutes the facile presumption that conditioning is nothing but a laboratory phenomenon with no laws of general

interests." (in Commons, Herrnstein, & Rachlin, 1982, p. 185) This then suggests that my use of operant principles to find the time horizons of rats has some ecological validity.

Though on the face it appears that there is a stark contrast in an animal's behaviour in its natural environment and in the laboratory, this may not necessarily be so. As point 3 states the two situations seem to be on some sort of a continuum. Research by Fantino (1977), and Lea (1979) have mimicked the contingencies found in foraging using conventional schedules of reinforcement and have found the predictions of optimal foraging theory to be borne out.

Still, the present study failed to reliably extend the time horizon in rats. There were problems with drawing firm conclusions from the results. Nevertheless, the present results suggest several lines for further study. First, the procedure could be tried with a shorter period of time for the PR schedule. Perhaps our results are not even related to a time horizon issue. Recall, Ferster (1953) had mentioned that the method was critical. Though I had presented arguments for using this procedure (see introduction), it may not be suitable. By decreasing the time period of the PR schedule, it would assure that the procedure is proper for investigating time horizons. Also, it might be worthwhile to have other groups that are exposed to variable (VI) or high fixed ratio (FR) schedules. In the present study, at the moment of choice, there is no difference in the two schedules. They both have the same kind of PR schedule, where at first, reinforcement is easy to obtain. Thus, there is no initial contrast between the two schedules. By using VI or a FR the schedules will

be difficult from the start. Third, by increasing the sample size we may be able to account for individual differences in each subjects. Fourth, it may be best to separate the patches/bars physically. That means the choice making entails moving to a new location for the other alternative. This may enhance ecological validity.

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