Observational Learning of Food Location by Rats

Presented to the faculty of Lycoming College in partial fulfillment of the requirements for Departmental Honors in Psychology

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The purpose of this series of experiments was to examine the ability of rats to use observational learning to find the location of food in a four-arm radial maze. In Experiment 1, 2, and 3 the rats had one observation session prior to all testing and the food was always in the same location. The hypothesis for the first three experiments stated that the observing rats would learn the task better than the non-observing rats. The data from Experiments 1 and 3 support the hypothesis. The data from Experiment 2 do not support the hypothesis. However, a post hoc analysis discusses how the results of all three experiments are consistent with Albert Bandura's social learning theory. In Experiment 4, the food was randomly placed in one arm of the maze prior to each test trial. The hypothesis stated that the observing rats would perform above chance level while the non-observing rats would perform only at chance level. The data support the hypothesis.

of Food Location

In human society, imitation, or observational learning, is considered by some to be the most often used method of learning (Bandura, 1977). It has been suggested that observational learning in rats could be just as important because it would be biologically advantageous (Calhoun, 1962 and Galef, 1990). The importance of research in this area was emphasized by Galef (1990) in the recent statement:

> "the question of whether animals can learn by imitation is theoretically important. Its definitive answer would help to resolve some venerable questions concerning the relationship of animal to human mind. Further, there can be no doubt that a robust, replicable demonstration of imitation learning, particularly by members of a non-primate species, would be a major empirical contribution, allowing otherwise impossible analyses of cognitive processes in animals" (Galef, 1990, p. 324).

Observational learning in rats has been investigated since before the turn of the century (Miller and Dollard, 1941 and Galef, 1990). Many early researchers found no evidence for imitation. In fact, Thorndike dismissed the possibility altogether (Thorndike, cited in Galef, 1990, p. 314). However, as experimental controls were applied (Groesbeck and Duerfeldt, 1971) and a greater understanding of the factors involved developed, results became more consistent in

favor of observational learning (Kohn and Dennis, 1972; Jacoby and Dawson, 1969; Corson, 1967 & Heyes and Dawson, 1990).

The early, inconsistent results were possibly due to a failure to control confounding variables (Groesbeck and Duerfeldt, 1971). For example, in Corson's (1967) study, the rats were permitted to follow the model. This gives the observing rat the opportunity not only to observe (Jacoby and Dawson, 1969), but to learn through direct experience. Groesbeck and Duerfeldt (1971) designed a crucial study to examine this and other variables that interfere in the studies of observational learning. In their study, following did influence the behavior of the rats. Mere exposure of a rat to the learning situation was also found to improve performance (Groesbeck and Duerfeldt, 1971). To control for this variable, the non-observing rats in the present series of experiments were exposed to the learning situation for the same amount of time as the observing rats.

Even with greater control of confounding variables, results about observational learning are inconsistent, difficult to repeat and produce debate among researchers (Galef, 1990). The current difficulties are possibly due to a failure to examine the experimental design in terms of the rat's physical limitations or in terms of the rat's normal social behaviors (Calhoun, 1962). In addition, the successful design of "truly arbitrary laboratory tasks minimizing the impact of instinctive behavior on performance" (p. 322) results in experimental designs that minimize if not eliminate social influences on behavior (Galef, 1990). John Calhoun (1962) agrees in The Ecology and Sociology of the Norway Rat when he writes that

"without knowledge of the experimental subject in its native haunts, one cannot hope to achieve maximum effectiveness in experimental design. . ." (p. 253).

An example of the failure to consider the rat's physical limitations is the failure to consider its visual capacity (Jacoby and Dawson, 1969). Albino rats have been shown to prefer the dimmest illumination available. More importantly, bright light had aversive qualities (Woodhouse and Greenfeld, 1985). Yet, many studies do not even mention the light conditions under which the testing was conducted (see Groesbeck and Duerfeldt, 1971). Thus, it may be assumed the studies were conducted in room light, considered "normal" for humans. As Slotnick and Katz (1974) state, researchers often "fail to take into account species differences in sensory capacities" (p. 796). In the present series of experiments, the light preference of the rat was considered by conducting all testing in low light levels.

Another example of a failure to consider the physical limitations as well as the normal social behaviors of the rat is failing to consider the task required. If the observing rats are experimentally naive, then it becomes particularly important to pay attention to the task required. For example, naive rats have not had an opportunity to learn that color cues may be something that needs their attention. The biological significance of the cues must be considered (Calhoun, 1962). Searching for food is a biologically important behavior and the use of observational learning to find food sources would be biologically advantageous. Also, the social

significance of food and the influence of conspecifics on a rat's diet has been well-documented (Calhoun,1962 & Galef, 1990). For example, it has been shown that a rat will follow a conspecific to a food site in a familiar situation (Galef, B., Jr., Mischinger, A., and S. A. Malenfant, 1987). In fact, it was difficult to get the rat not to follow (Galef, B., Jr., Mischinger, A., and S. A. Malenfant, 1987). In addition, a colony of rats will avoid food that has made one of its members sick (Lore and Flannelly, 1977).

The present series of experiments was intended to study the ability of rats to use observational learning to find the location of the food in a four-arm radial maze. In the first experiment the observing rats had one observation session prior to all test trials and the food was always in the same location. The hypothesis stated that the observing rats would learn the task better than the non-observing rats.

Experiment 1

Method

Subjects

Subjects were 11 experimentally naive albino rats. One rat was randomly selected as the model. All other rats were randomly assigned to the observing group or non-observing group. The rats were 90 day old males.

Materials

A four-arm radial maze was constructed of plywood and painted black. Each arm measured 18 inches. The central area, measuring 15 inches x 15 inches, was accessible from four doorways,

one door between each arm of the maze (See Figure 1-A). A clear, plastic five-gallon aquarium was used as the observation box. It was placed directly above the central area on top of a sheet of clear Plexiglass. The arms of the maze were covered with wire mesh, painted black. At the end of each alley a round lid was nailed to the floor of the alley. The room was lit by one 45 watt bulb placed under the table that supported the maze.

Design and Procedure

The maze sat on a table 31 inches above the floor in a quiet room. Its position remained constant throughout all trials. The amount of illumination in the room was kept at a constant level also. The food reinforcer, crushed laboratory rat chow, was placed in the lid at the end of Arm 2. The food was always in this location and the lid was kept full. The experimenter stood in the same location for all trials.

Ten rats were randomly assigned to one of two groups. Group 1 observed a model rat find the food before testing. Group 2 did not have the opportunity to observe before testing.

The subjects were tamed over a period of two weeks with daily handling. All animals were then placed on deprivation and kept at 85% of free-feeding weight. Observation and testing began ten days after placing the animals on deprivation. The teacher rat was trained and familiarized with the radial arm maze prior to being observed. However, during observation periods, the teacher rat was forced to choose the correct arm by blocking the entrances to the other three

arms with clear, plastic doors. The subjects were trained and tested over a period of 14 days.

The observing rats were trained by placing each one in the observation box and allowing it to observe the teacher rat find the food four times. Time was recorded but no limits were imposed. For the non-observing rats training consisted of sitting in the observation box for the recorded time period. Twenty blocks of four trials were run for each rat. A trial consisted of placing the animal in the central area through one of the four doors and allowing the rat to make one choice. The entrances were randomized in blocks of four trials with the stipulation that each entrance occurred only once during each block of four trials. Rat 1, an observing rat, was given an unlimited amount of time to make choices for the first forty trials. Rat 2, a non-observing rat, was given an unlimited amount of time for the first six trials. Because Rat 2 took forty minutes to make only six choices it was decided to impose a time limit of twenty seconds for each rat to make a choice. After that time it was removed and a non-choice was recorded for that trial. If the rat made an incorrect choice it was immediately removed from that alley and placed in its home cage until the next trial. If the rat made a correct choice it was allowed to eat for 15 seconds before removal. A complete record was kept of choices and non-choices.

Results

Scores were grouped into blocks of four trials for all rats. Learning curves were plotted for each rat (see Figure 2-A and 2-B) showing the percent correct for each block of four trials. Learning

curves for each group were also plotted showing mean percent correct for each block (see Figure 2-C). Only one of the five rats in the non-observing group ever achieved 100% correct. That one rat did so on only three blocks of trials. Of the observing rats, four of the five rats achieved 100% correct on a total of seventeen blocks of trials. As a group, the non-observing rats performed at or below chance (25%) on six blocks of trials (out of a total of 20). The observing rats performed at or below chance on only one block.

Discussion

The results support the hypothesis. That is, the observing rats learned the task better than the non-observing rats. However, the individual learning curves raise some questions. For example, why did one non-observing rat score 100% for the first block of trials? During those early trails the rat did not eat or even seem to notice the food. Yamamoto, Wapner, and Stevens (1980) have found that rats will explore an unfamiliar area by starting from a familiar location. This familiar location becomes the base of operations, or anchor point, for further explorations. It is possible that the rat selected Arm 2 by chance on its first trial. This chance selection made Arm 2 the more familiar location and thus became the rats anchor point. Upon entering the maze, it returned to the anchor point from which it would have explored the rest of the maze if given the chance.

Another question concerns the 0% that some of the rats obtained after clearly showing learning at the 75% and 100% levels. One possibility is that the rats were spontaneously alternating to

another choice after several choices at one location (Gaffan and Davies, 1982). In addition, the rats hesitation to make a choice could also be due to spontaneous alternation. The struggle between having been rewarded for returning to the same location and the tendency to alternate to another choice may have temporarily caused the rat to pause in his movements. This would have been scored as a non-choice if the pause lasted longer than twenty seconds. The recording of non-choices skews the results in a negative direction since the scoring method (percent correct) treats non-choices as incorrect choices. Different activity levels of rats might also influence the tendency to make a choice or not. Activity levels were not controlled in this study.

In spite of these possible explanations, the experimenter observed behavior by the rats that indicated the possibility of a confounding variable that allowed the rats to detect which arm contained the food. Some of the rats would sit at the entrance to each arm for a few seconds. After all four alleys had been inspected in this manner, the rats would then make the correct choice. It is possible that the crushed food smelled differently than the solid cubes of food intended to mask the location of the food reward. Also, sometimes freshly crushed food was used while other times the crushed food had been airing out for several hours. This may have contributed to an odor difference that the rats were able to learn. The experimenter also noticed, after most of the testing was completed, that some of the rats spilled food from the food cup onto the floor of the maze. This would have provided a visual cue for

subsequent trials. In addition, it was noted that some of the rats seemed to pay more attention to the experimenter than to the model.

A larger maze was constructed to remedy these problems. With a larger central area, the observation box could be placed on the floor of the central area instead of above it so that the observing rat would be more likely to notice the model rat and not the experimenter. In addition, a block of wood was put in each alley to block the visual path to the food cup. Because of these changes, it was deemed necessary to repeat the experiment using the new maze. The hypothesis stated that the observing rats would learn the task better than the non-observing rats.

Experiment 2

Method

Subjects

Subjects were 11 experimentally naive albino rats. One rat was randomly selected as the model. All other rats were randomly assigned to the observing group or non-observing group. The rats were 90 day old males.

Materials

A four-arm radial maze with a larger central area (27 inches across) was constructed of plywood and painted black (see Figure 1-B). Each arm measured 5 X 18 inches. A seven-inch square, bottomless observation box, constructed of Plexiglass, was located in the center of the open area. One inch in front of each food cup was a 1 X 1 X 5 inch block of wood painted black to block the view down

the alley. Holes drilled in the back of the blocks were filled with the food reward to mask the food odor from the food cup.

Design and Procedure

Same as in experiment 1 except for three changes. A box to cover the observation box was made from black poster board. It was placed over the observation box after the observation session while the clear plastic doors were removed just prior to testing. In addition, the rat was released from the observation box for the first trial before randomly placing the rat through the one of the four doors. Also, only 19 blocks of trials were run for each rat instead of 20.

Results

Learning curves were plotted for each rat that show the percent correct for each block (Figure 3-A and 3-B). Learning curves were also plotted using the mean scores for the observing and non-observing groups (see Figure 3-C). Overall, the two groups performed similarly. Three of the non-observing rats scored at the 100% level on a total of thirteen blocks of trials while four of the observing rats scored 100% on seven blocks. As a group, the non-observing rats scored at or below chance on three blocks of trials. The observing rats scored at or below chance on four blocks. The observing rats first performed above chance on the second block while the non-observing rats did not perform above chance until the fourth block of trials.

Discussion

The results do not support the hypothesis. That is, the observing rats did not learn the task better than the non-observing rats. However, the observing group may have been attempting to use the information from the observation sessions since they performed above chance earlier than the non-observing group. The experimental design of this study may account for the rats' poor use of the information gained through observation. Because testing after the observation session was for 76 trials, the rats were able to use trial and error learning to find the food. Use of observational learning was not necessary nor did it become the preferred method. In fact, the opposite may have occurred, i. e., the rats may have been reinforced more for trial and error learning. Further research could eliminate the use of trial and error learning so that any use of observational learning would be more apparent.

An important question is why in Experiment 1 did the observing rats learn the task better? Any visual cue that may have been present in the first experiment would have been present for all rats, not just the observing rats, and does not fully account for these differences. The experimenter noted than in this study, the rats in the newer observation box seemed to spend more time grooming than the rats used in the first experiment. The new observation box, constructed of Plexiglass, reduced if not eliminated the observing rat's ability to use hearing and smell to help locate and track the model rat. It has recently been shown that rats learn discrimination tasks better with auditory cues than with visual cues (Tees, R. C. and

& Buhrmann, K., 1989). This suggests that rats do not rely equally on each sense for information and that expecting rats to rely only on vision (as in experiment 2) for information may not be a realistic expectation, particularly when taking into account their poor vision.

Albert Bandura's (1977) social learning theory, based on years of imitation research with children, suggests that increasing the interaction between model and observer increases the likelihood of observational learning occurring. This suggested that an observation box that allows the observing rat to interact with the model using hearing and odor as well as vision should be used. In addition, social learning theory argues that an understanding of the consequences increases the likelihood of observational learning.

A third experiment was planned and implemented using just such an observation box as suggested above and employing a procedural change to aid the observing rat in associating the model rat with food. The new observation box was essentially a small, bottomless cage that even allowed the rats to touch noses. The procedural change was giving the model rat three pellets of food in the central area while the observing rat watched and just prior to the model finding the food in Arm 2. The hypothesis stated that the observing rats would learn the task better than the non-observing rats.

Experiment 3

Method

Subjects

Subjects were six experimentally naive rats randomly assigned

to either the observing or non-observing group. All rats were 70 day old albino male rats. A model rat was randomly selected from the rats used in Experiment 2. The model was a 120 day old albino rat.

Materials

The same as above except for the use of a new observation box. The new observation box was a bottomless cage that measured 8 inches long by 7 inches wide by 6 inches high.

Design and Procedure

Same as above with the following changes: The rats were placed on a twelve hour night/twelve hour day schedule (previously the light was on twenty four hours a day). Hopefully, the rats would then be more active during their twelve night time hours (the experimenter's day time hours) and therefore the number of non-choices would be reduced.

In addition, three procedural changes were made. The model rat was given three pellets of food in the central area while the observing rat was in the observation box and just prior to the model finding the food in Arm 2. Also, the twenty second time limit was imposed only if the rat froze in its movements for twenty seconds. As long as the rat was moving it was allowed to continue. The third change was allowing the observing rat to observe the model find the food eight times instead of four.

Results

Learning curves were plotted for each rat (see Figure 4-A and 4-B) and for each group (see Figure 4-C). Only one of the observing

rats scored 100% correct--and it did so on eight out of 20 blocks of trials. Only one non-observing rat scored 100% correct and it did so on seven out of 20 blocks of trials. As a group, the observing rats did not perform at or below chance on any trial. The non-observing group performed at chance level on four out of 20 blocks.

Discussion

The results support the hypothesis. That is, the observing rats learned the task better than the non-observing rats.

A post hoc analysis of the performance of the observing rats in Experiments 1, 2, and 3 shows that the results are consistent with Bandura's social learning theory. That is, the more ways the observing rat had to interact with the model, the better the observing rats performed, just as Bandura's theory would predict (see Figure 5). For example, the observing rats in Experiment 2 had only one way of interacting (vision) and performed at chance level four times, more than the other two observing groups. The rats in Experiment 1 could interact in two ways--vision and hearing--and performed at chance level one time. The best performance was by the rats in Experiment 3. There were four possible ways of interacting--vision, hearing, smelling, and touching--as well as help in connecting the model rat with food. The observing rats in this group did not perform at chance level on any block of four trials. In a review of research on imitative behavior--including research with rats, James Flanders (1968) concluded that Bandura's imitation viewpoint "is best able to cope with existing findings." (p. 332). Further research intending to examine the predictions of social

learning theory and observational learning should be conducted.

Other factors thought to influence observational learning could also be investigated. For example, an examination of the effects of prior experience on observational learning can be conducted. Could the observing rats learn to make better use of the information available to them through observation with continued experience? It has been suggested that observational learning is a learned behavior (Miller and Dollard, 1941). Reinforcement for imitation was not controlled in this study although it has been found to be possible to train animals to learn to imitate (Miller and Dollard, 1941). Experience with observational learning has been shown to increase performance and learning among children (Bandura, 1977). Further research should take into account the previous experience of rats with observational learning.

One such experiment was planned and implemented. This experiment examined the influence of prior experience by allowing the rat to observe prior to each test trial. In addition, trial and error learning was eliminated to make it easier to attribute any learning to information gained through observation. As mentioned in the discussion for Experiment 2, the rats in that experiment and in Experiment 1 and 3 were able to use two methods of learning to find the food: observational and trial and error. If trial and error learning were eliminated, then any learning that occured could more easily be attributed to observation. To accomplish this, the food was randomly placed in one of the four arms of the maze prior to each observation session followed by only one test trial. The hypothesis stated that

the observing rats would perform above chance level while the non-observing rats would perform only at chance level.

Experiment 4

Method

Subjects

Subjects were four experimentally naive albino rats randomly assigned to the observing group or non-observing group. The subjects were 100 day old males. An experimentally experienced 150 day old albino male rat was randomly selected to be the model from the rats used in Experiment 2.

Materials

Same as in Experiment 3 with the following changes: A floor covering was made of black poster board and covered with clear contact paper. It was cut in eight sections, one for each alley and four equal sections for the central area. In addition, a wood partition was placed between the maze and the experimenter sitting area to block the rats' view of the experimenter. The black, poster board cover box was placed over the observation box between each trial of the model rat so that the observing rat could not see the experimenter add food to the food cup during the observation sessions or just prior to testing. Fishing line was tied to the observation cage and and the black cover box so that the cages and cover could be lowered or raised by the experimenter from behind the partition.

Design and Procedure

Same as in Experiment 3 with the following changes: A

different food reinforcer, three Noyes precision pellets, was randomly placed in one of the arms with the stipulation that each arm occured only once in every four trials. The starting point for the model was randomly assigned to one of four areas in the central area. Each observing rat was given the opportunity to observe the model rat four times. The observation cage was then covered so that the floor covering and the clear, plastic doors could be removed. The observation cage and cover were then raised so that the observing rat could make a choice. Only one choice was allowed and then the food was randomly assigned to a different arm and the procedure repeated. In this way, the only way for the rat to find the food at a greater than chance level is to use observational learning. Seven blocks of four trials were run for each rat over a period of three weeks. The non-observing rats were allowed to observe the test situation for the recorded time period before making their choice. Since the food was randomly distributed among the arms, the non-observing rats would be expected to perform only at chance level.

Results

Learning curves were plotted for each rat (see Figure 6-A and 6-B) and for each group (see Figure 6-C). Of the observing rats, Rat 1 performed at the zero percent level only one time and Rat 2 did not perform at the zero percent level on any trial. Of the non-observing rats, Rat 3 performed at the zero percent level on three trials while Rat 4 performed at the zero percent level on four trials. In addition, the observing rats performed above chance level for four of the

seven blocks of trials while the non-observing rats performed above chance level on only one of the seven blocks.

Discussion

The data support the hypothesis. That is, the observing rats performed above chance level while the non-observing rats performed at chance level. While one of the non-observing rats did score at above chance level on two blocks, this could be due to chance. This possibility is supported by the fact that the rat scored at chance level on all other trials.

The observing rats did seem to improve their performance a little as they gained experience. If more trials were conducted even more improvement in performance might be observed. In addition, the observing rats performed above chance level on the first and second trials, which suggests that prior to testing the rats could use observational learning. This does not lend support to Miller and Dollard's (1941) contention that imitation must be learned, although, as they predict, experience in this experiment did improve performance. However, experience with observational learning prior to testing was not controlled. It is known that the rats were housed in groups of 3-6 rats up to the age of 60 days. Future experiments could use this method to assess use of observational learning in rats that have had no prior experience in a social setting and thus possibly no experience with observational learning.

The influence of other variables on observational learning could also be assessed using this method. For example, could internal

cues help the rats use observational learning? Spatial memory studies have shown that rats use external cues for orientation in the maze (Olton, D. S., Collison, C., & Werz M. A., 1977). However, the use of external versus internal cues has not been assessed with observational learning. In this experiment, there were many external cues for location, but there were no internal cures, i.e. each arm looked much the same as all the other arms. Future experiments could examine the influence of internal cues.

Another possible influence to investigate is the presence of the experimenter. Bandura (1977) has shown that children given more than one model are more likely to imitate the model who is in control and has the most power. Since the experimenter gave all rats their daily maintenance weight it seems likely that the rats learned to associate the experimenter with food. In addition, the experimenter was seen to handle the model rat (i.e. control the model). Would these circumstances influence the observing rats to pay more attention to the experimenter than to the model rat? Could the experimenter have become the preferred model? Observations by the experimenter suggested that the rats did at times pay more attention to the experimenter than to the model, despite the wood partition. A post hoc analysis on rat choices was done to see if the data lend support to this observation. Since the experimenter was standing near Arm 2 and was at the end of Arm 2 when placing the model in the central area, the presence of the experimenter might have influenced the rats to choose Arm 2 more often. In fact, the data support this possibility (see Figure 7-A and 7-B). For example,

20 of 56 possible choices (correct or incorrect) for the observing rats were for Arm 2. The fewest choices were for Arm 3 (8). The non-observing rats' choices (correct or incorrect) were similarly distributed, although the differences are smaller. The most choices were for Arm 2 (18) and the fewest for Arm 3 (12). The number of correct choices out of all possible correct choices for each arm indicates even greater differences. For example, out of 14 possible correct choices for each arm, the observing rats chose Arm 2 eight correct times while they only chose Arm 4 one correct time. Arm 4 was the farthest arm from the experimenter. The non-observing rats chose Arm 2 four correct times out of a possible 14 times while Arm 4 was chosen only one correct time. The data suggest that future experiments should be set up to eliminate the association of the experimenter with food or the presence of the experimenter during testing.

Additional observations by the experimenter indicated the possibility that when the observing rats made a choice, they sometimes failed to account for shifts in position made while the cover box was over the observation cage. When the observing rat was in the dark, it had no cues available to indicate it's new position relative to the model's chosen arm. No data was kept to support this observation, but future experiments could test the use of a topless cover box. Distinct cues above the rat might then help the observing rat maintain its orientation while the experimenter could still place food in the arm unobserved.

General Discussion

Finding a method to reliably test factors influencing observational learning has been a continued difficulty for researchers. This method, observational learning of food location in a radial maze, could be used and might prove to be more reliable than other past methods. This method takes into account the biological significance of the task as well as the social influences on rats concerning diet. In addition, the method in Experiment 4 eliminates the influence of trial and error learning so that any learning can more easily be attributed to observational learning.

In addition, the results of these experiments, particularly the first three, indicate the need to have a guiding theory. As Flanders (1968) states, "the more the results of any potential imitation study bear directly upon the elements of a good imitation viewpoint, the more valuable the study is likely to be" (p. 332). Use of this method could examine and compare the predictions of Bandura's social learning theory with other theories of observational learning. As Galef (1990) so aptly stated, an examination of the factors involved in observational learning, one aspect of social learning, has "the potential to make fundamental contributions to our understanding of processes supporting the development of adaptive behavioral repertoires in free-living animals" (Galef, 1990, p. 325) as well as to "resolve some venerable questions concerning the relationship of animal to human mind" (Galef, 1990, p. 324).

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Figure 1-A

The first maze

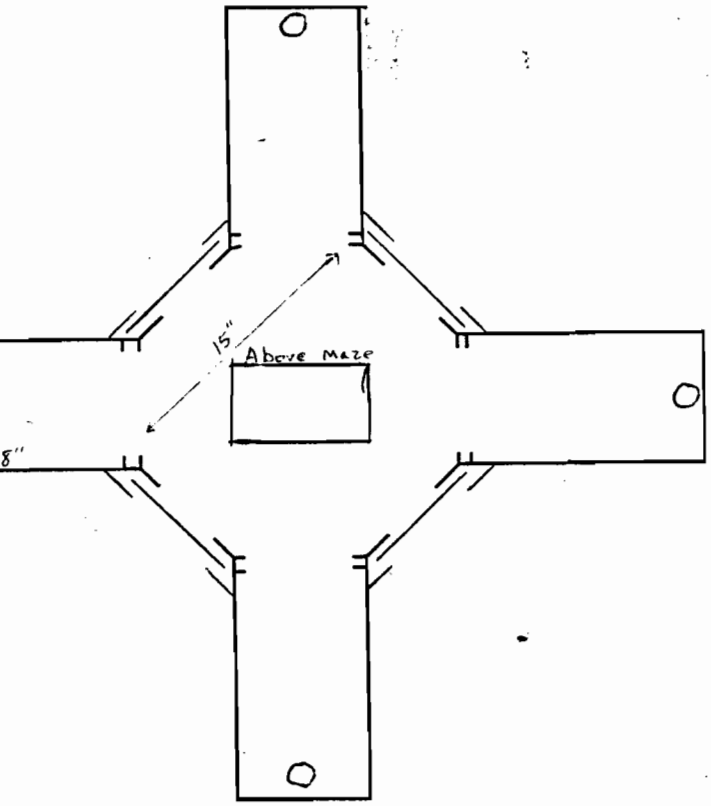


Figure 1-B

The second maze

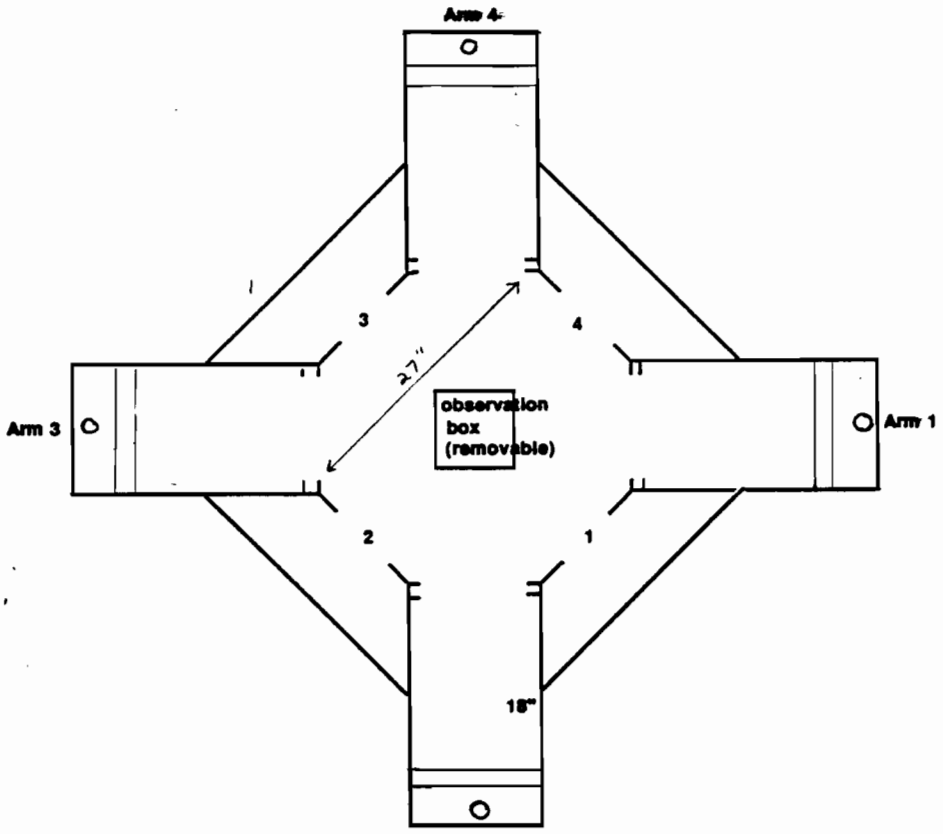
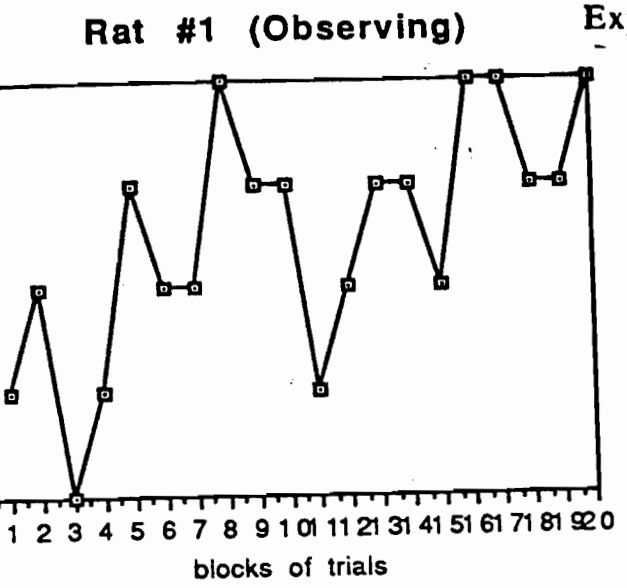
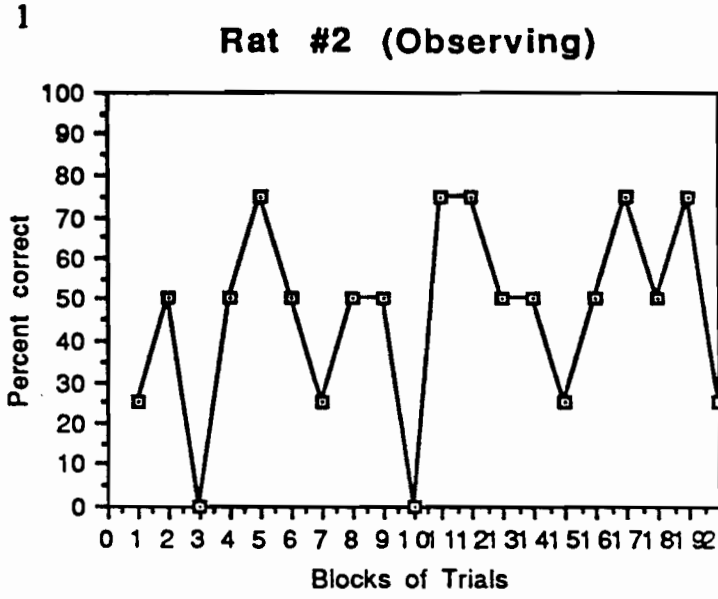
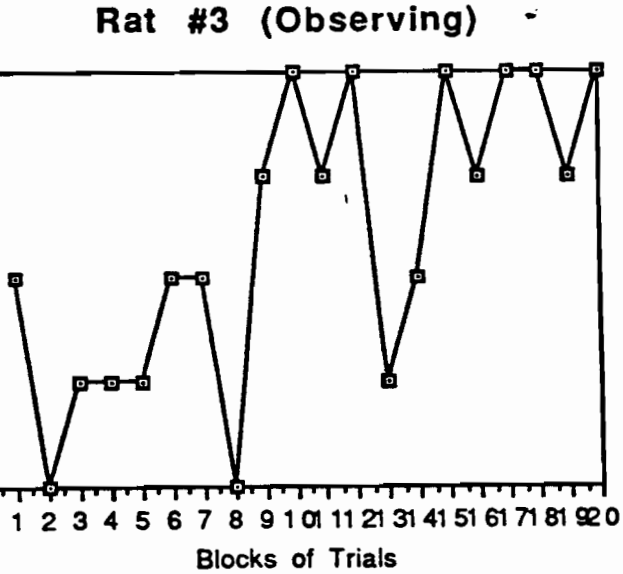
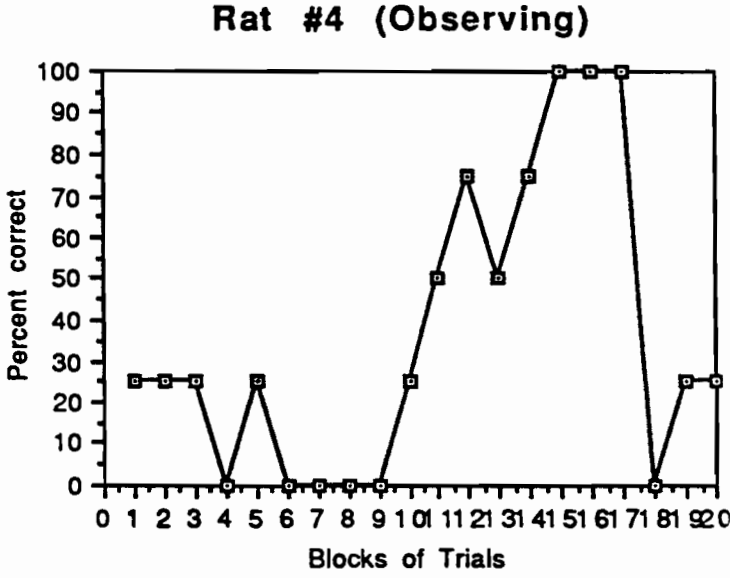


Figure 2-A
Percent Correct (Observing Rats)
Experiment 1









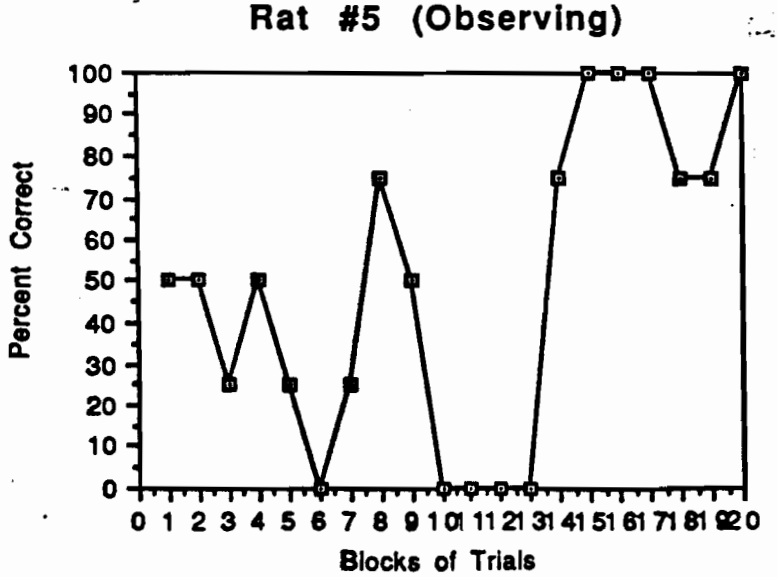
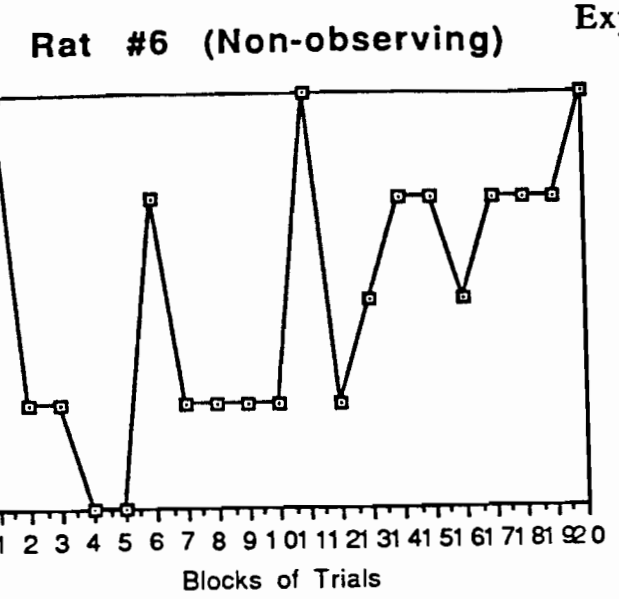
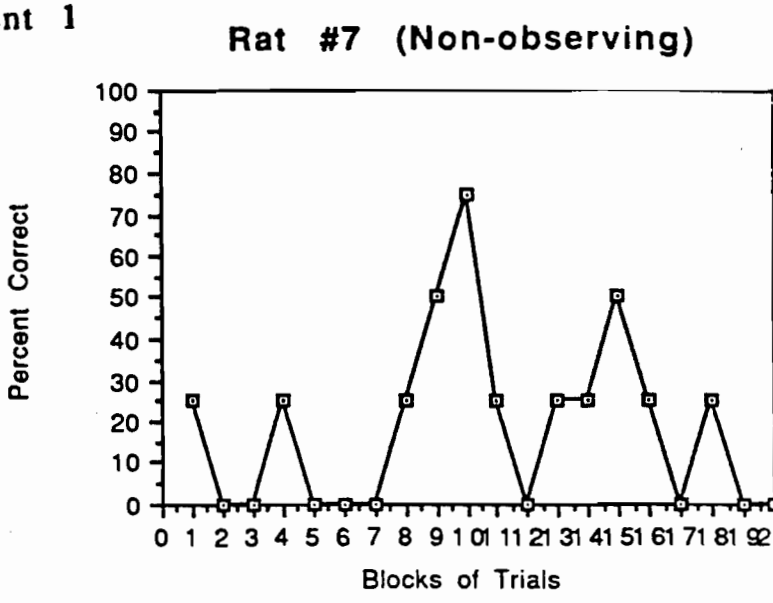
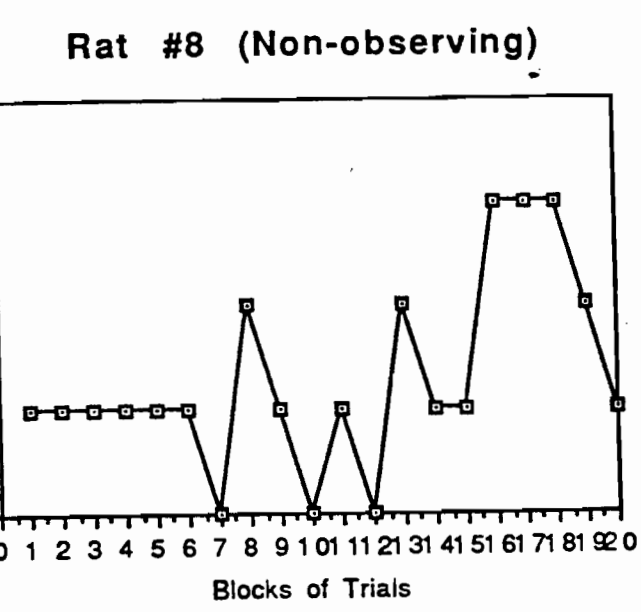
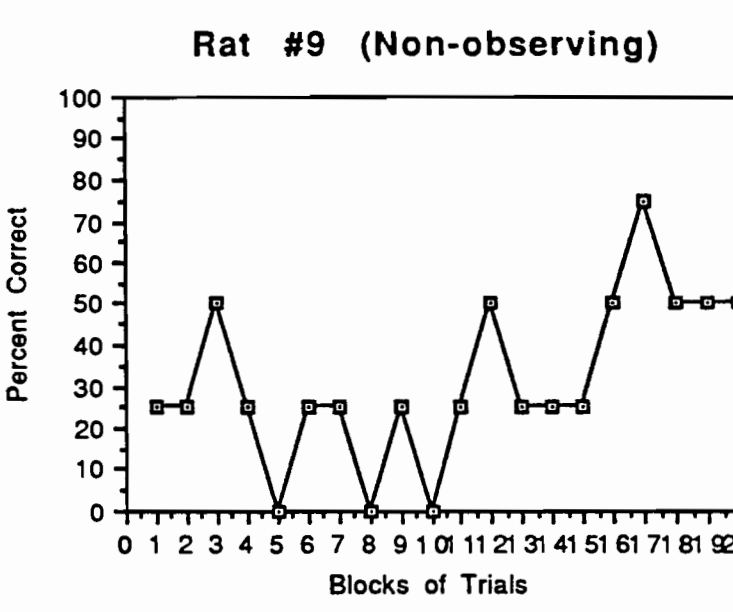


Figure 2-B
Percent Correct (Non-observing Rats)
Experiment 1









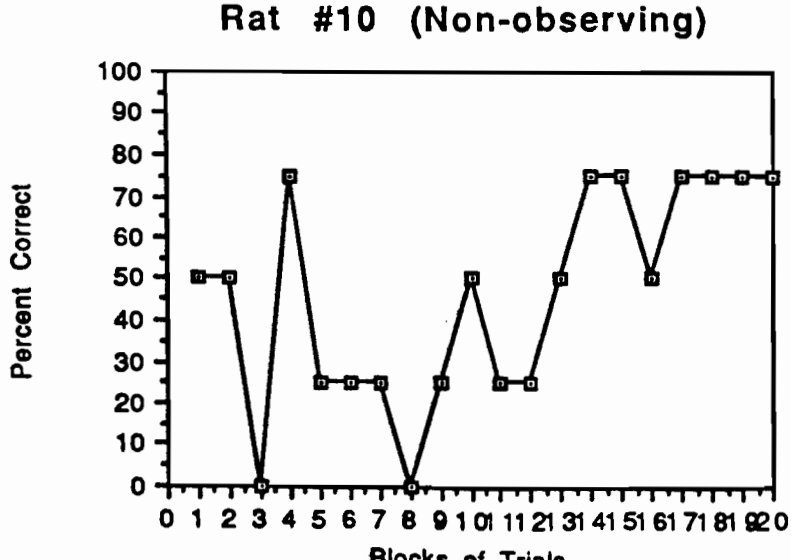


Figure 2-C
Mean Percent Correct
Observing and Non-observing Rats
Experiment 1

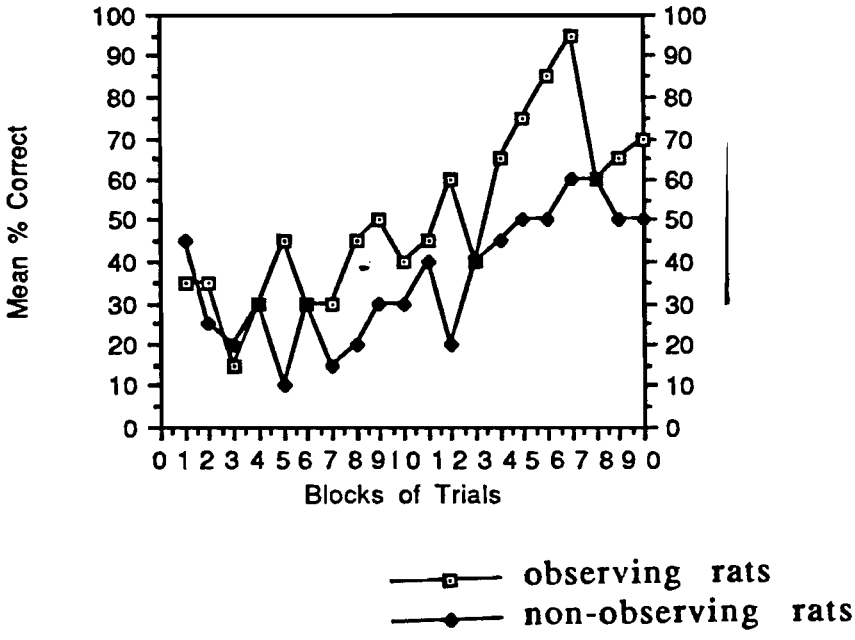
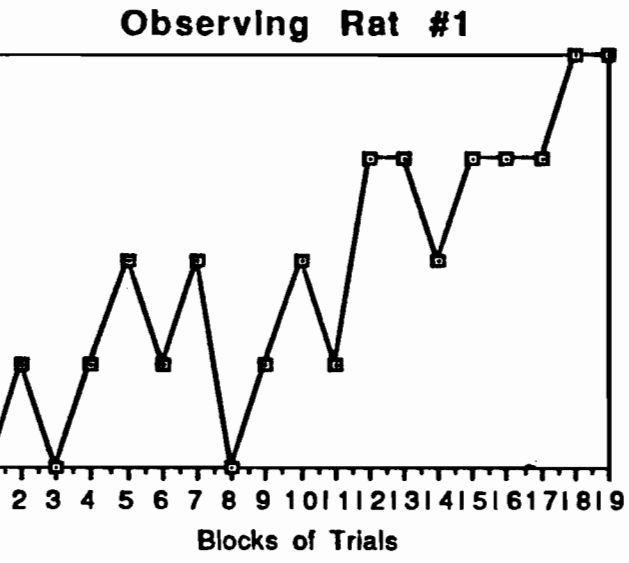
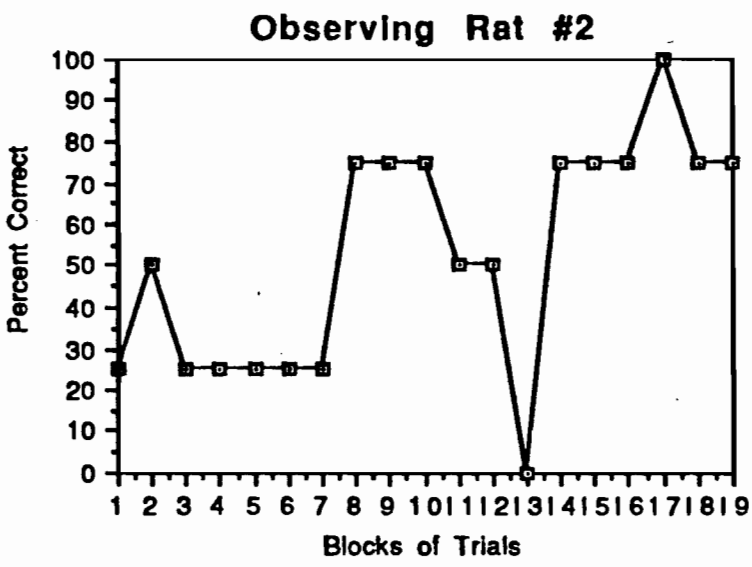
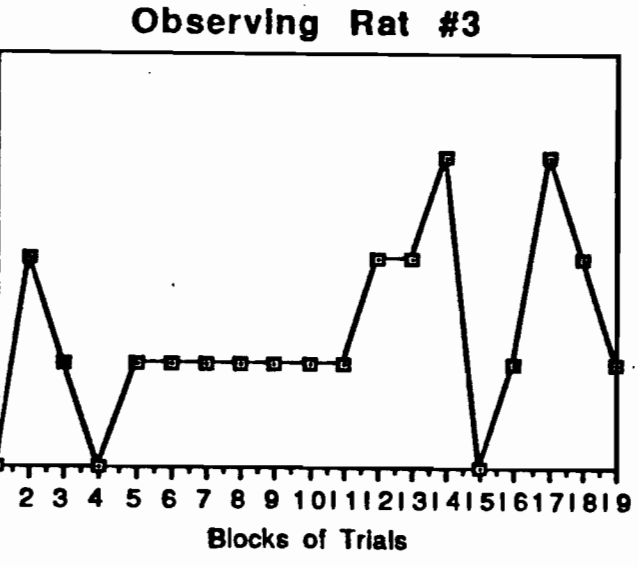
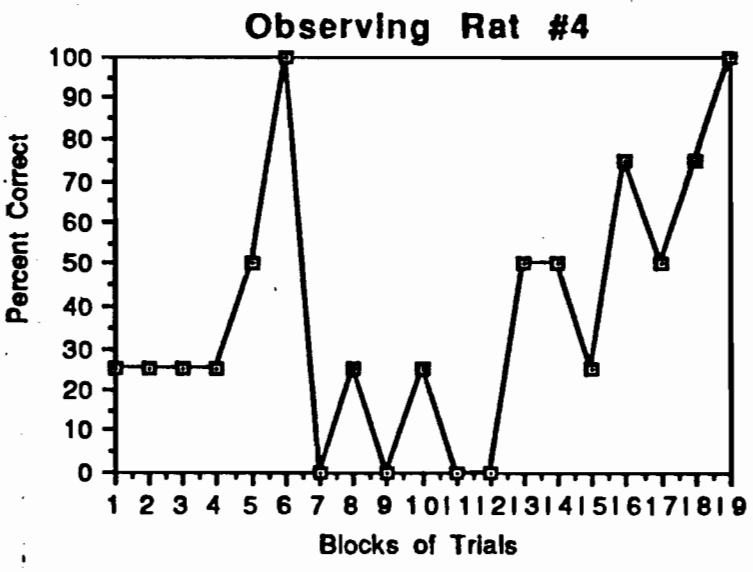


Figure 3-A
Percent Correct (Observing Rats)
Experiment 2









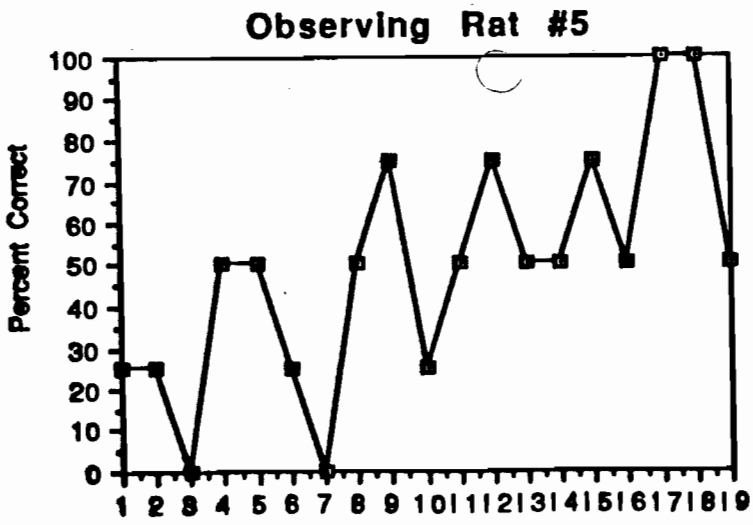
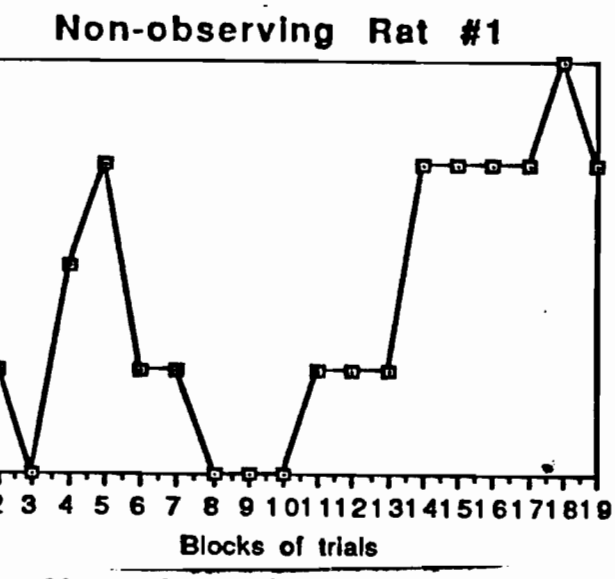
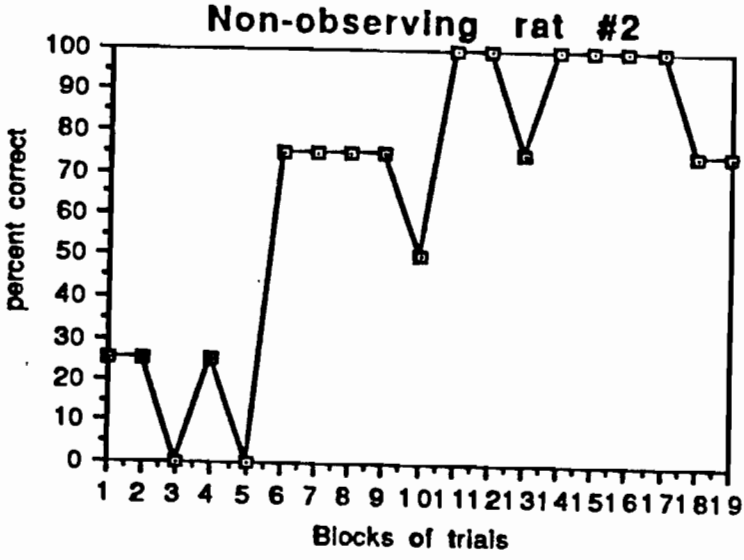
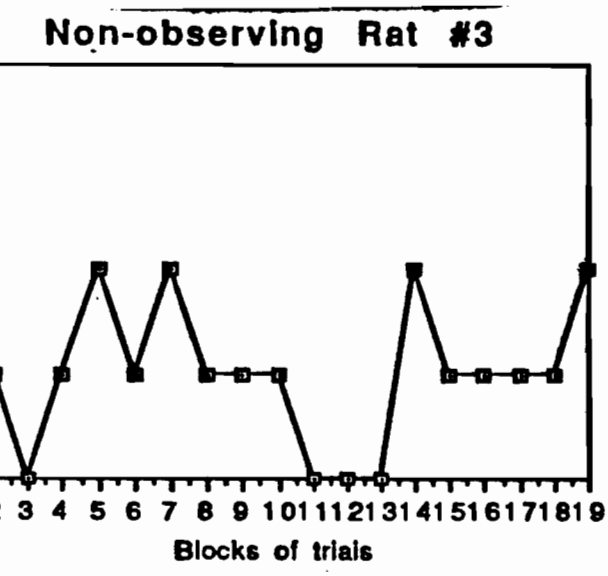
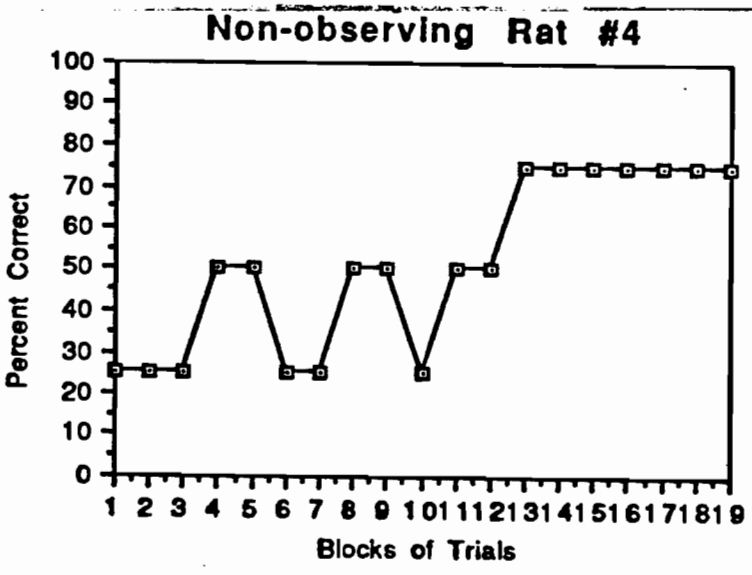


Figure 3-B
Percent Correct (Non-observing Rats)
Experiment 2









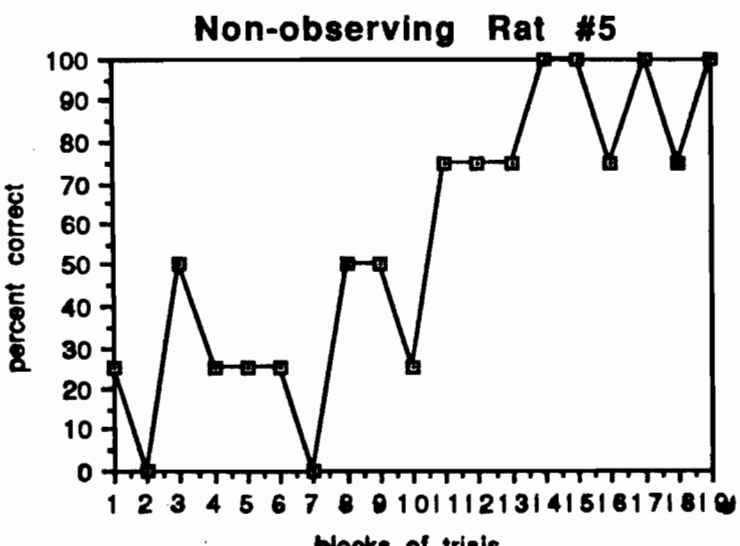


Figure 3-C
Mean Percent Correct
Observing and Non-observing Rats
Experiment 2

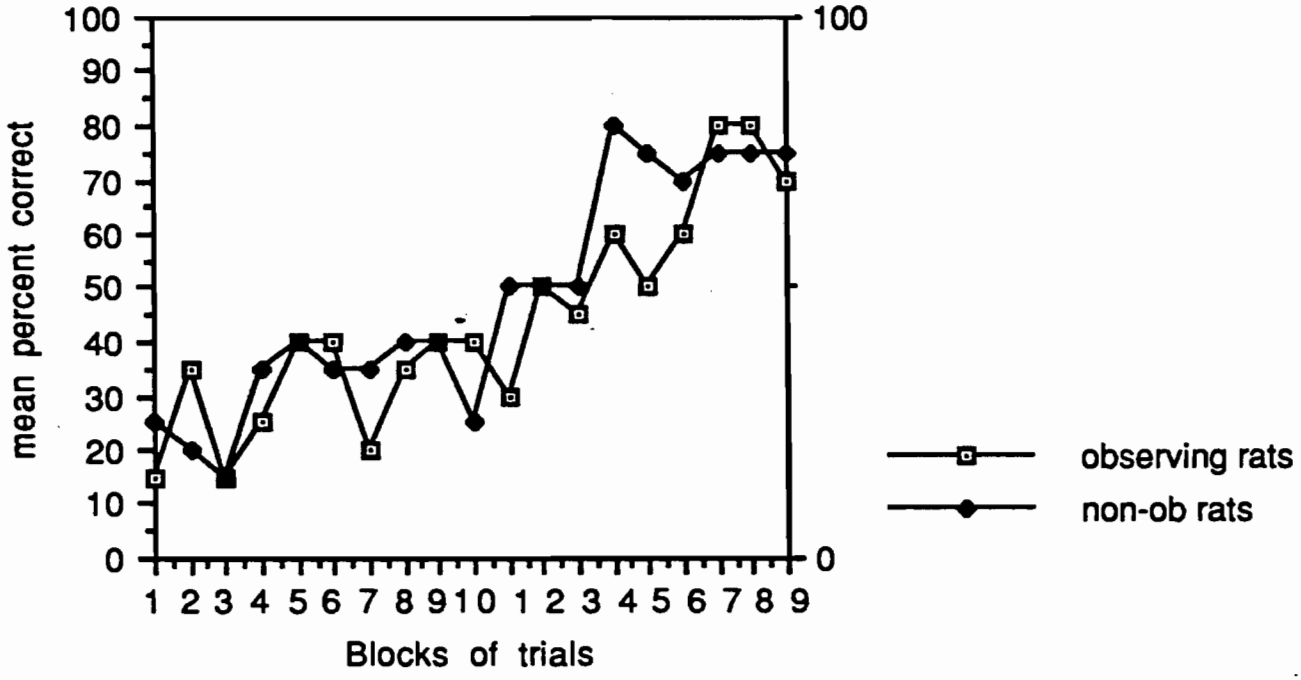
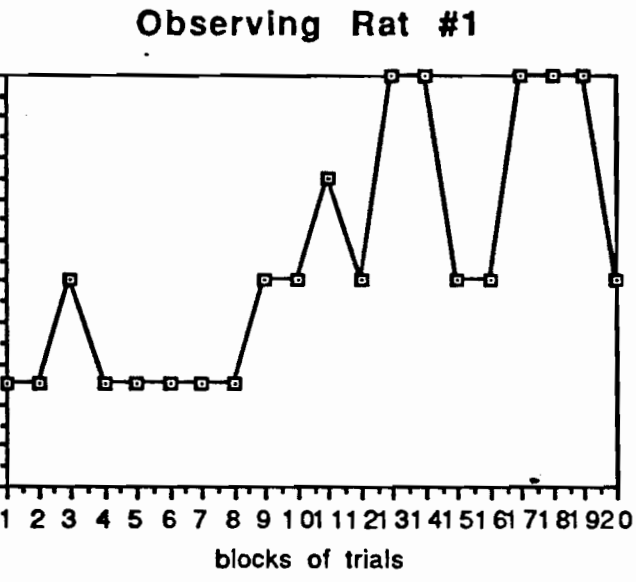
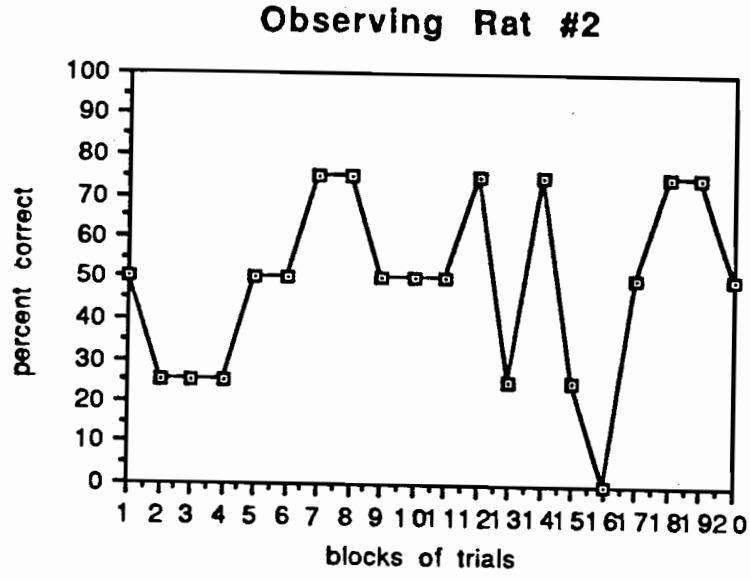


Figure 4-A
Percent Correct (Observing Rats)
Experiment 3





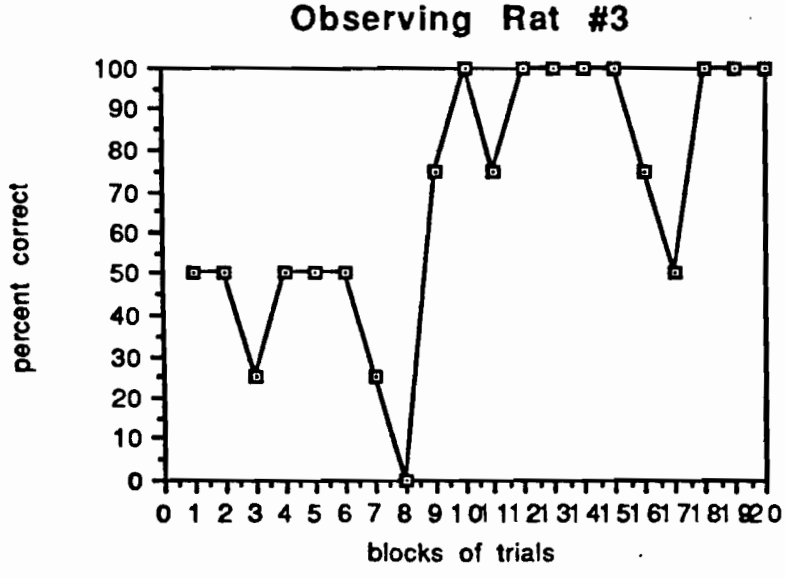
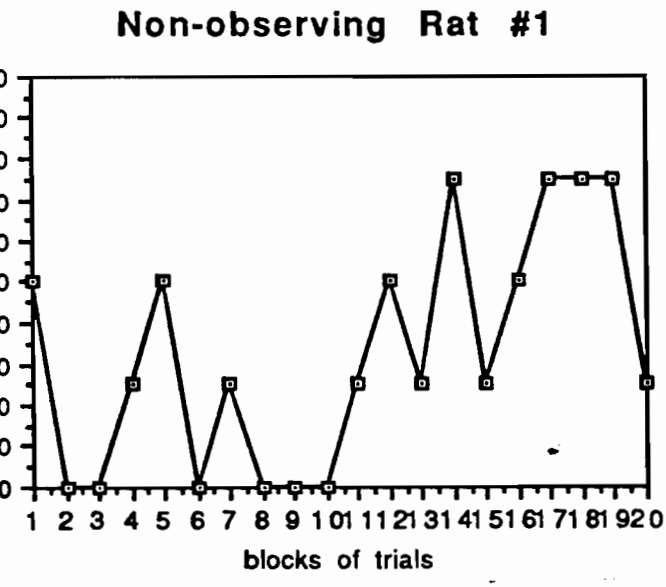
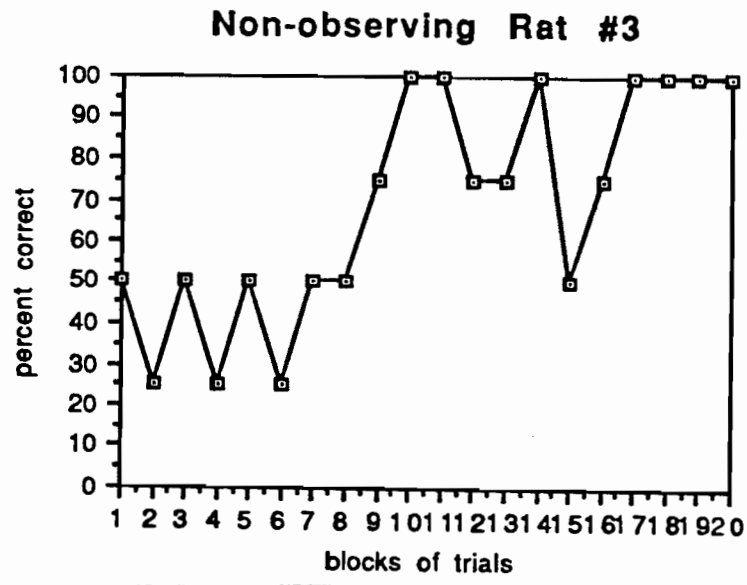


Figure 4-B
Percent Correct (Non-observing Rats)
Experiment 3





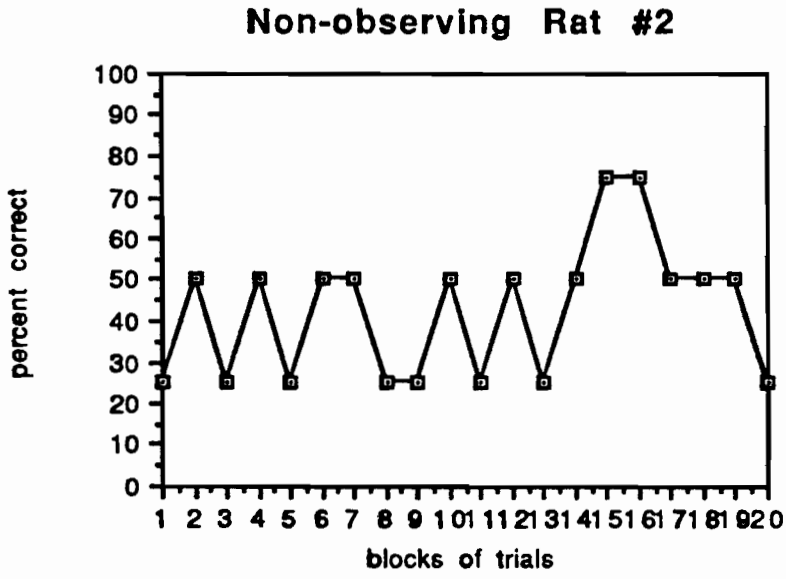
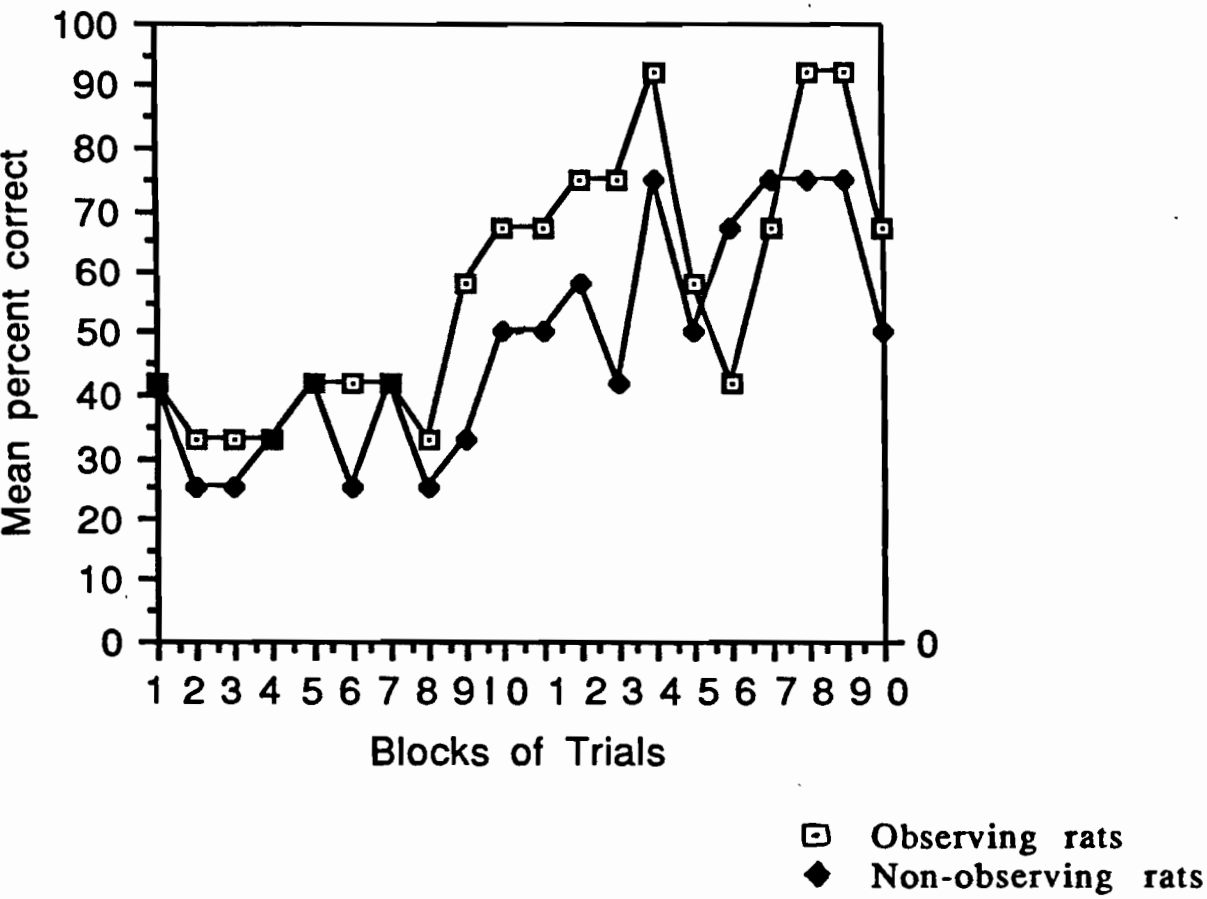


Figure 4-C
Mean Percent Correct
Observing and Non-observing Rats
Experiment 3



Observing Rats
Experiments 1, 2, and 3

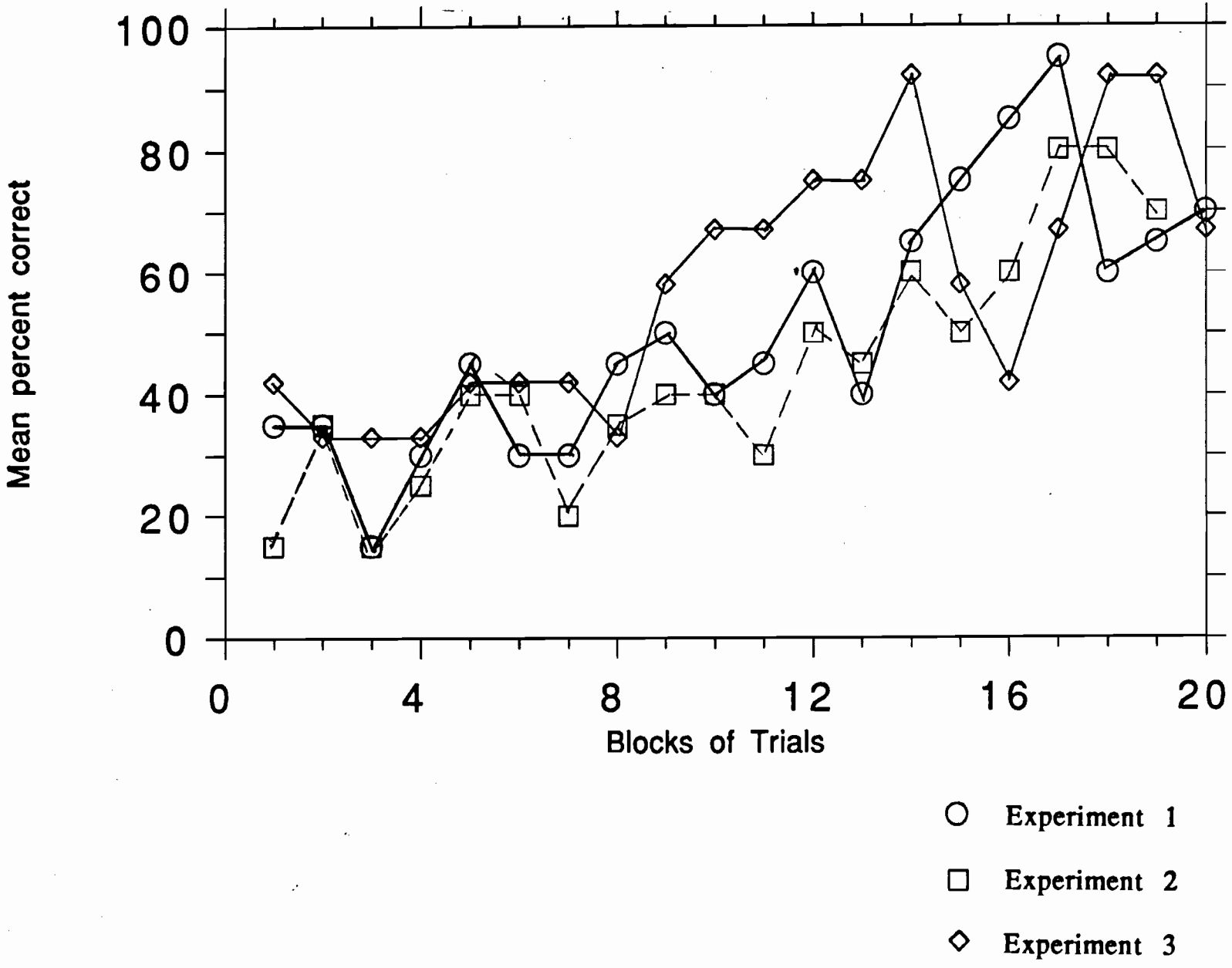
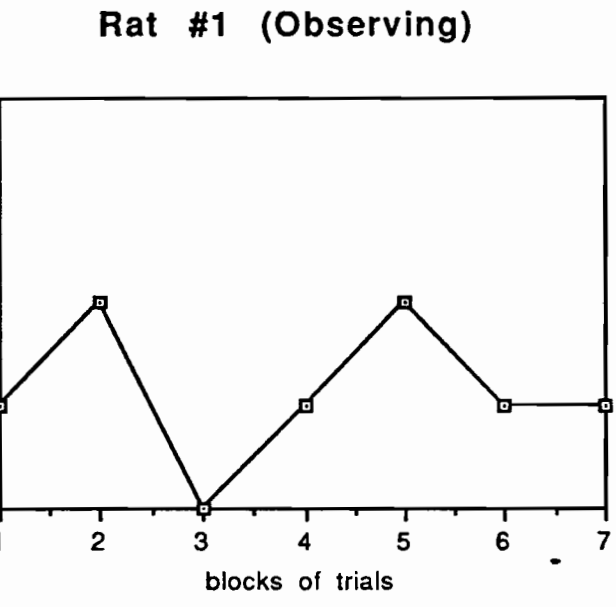


Figure 6-A
Percent Correct (Observing Rats)
Experiment 4



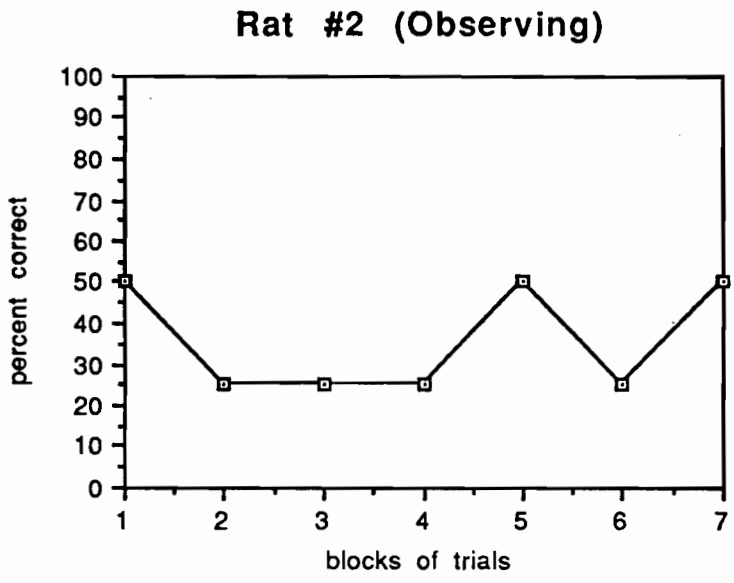
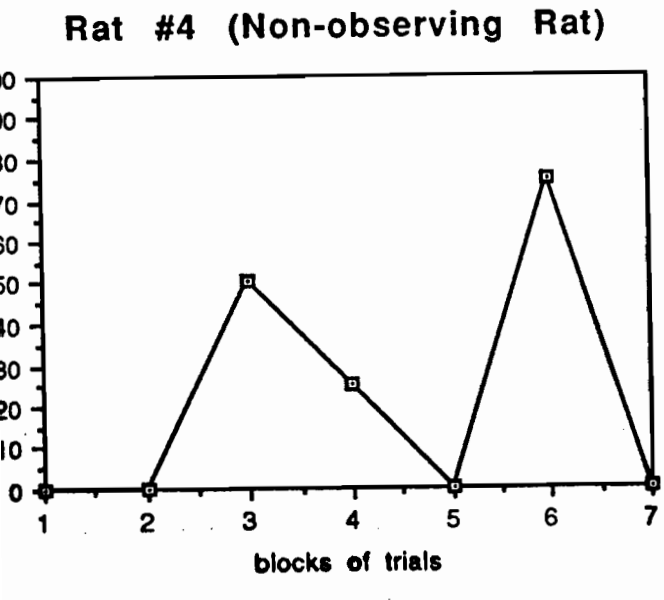


Figure 6-B
Percent Correct (Non-observing Rats)
Experiment 4



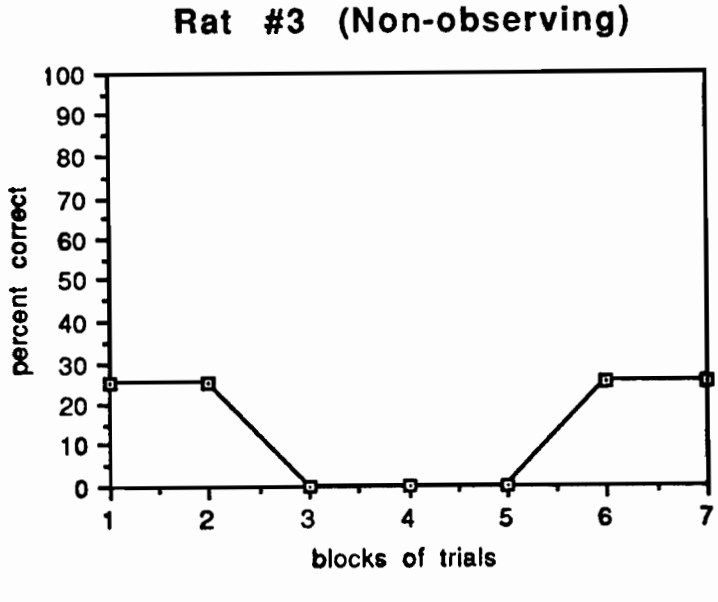


Figure 6-C
Mean Percent Correct
Observing and Non-observing Rats
Experiment 4

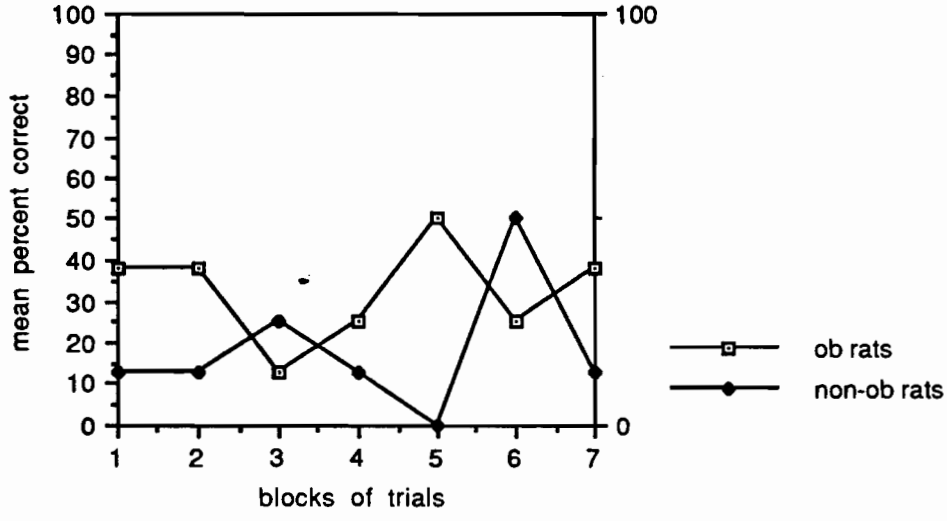
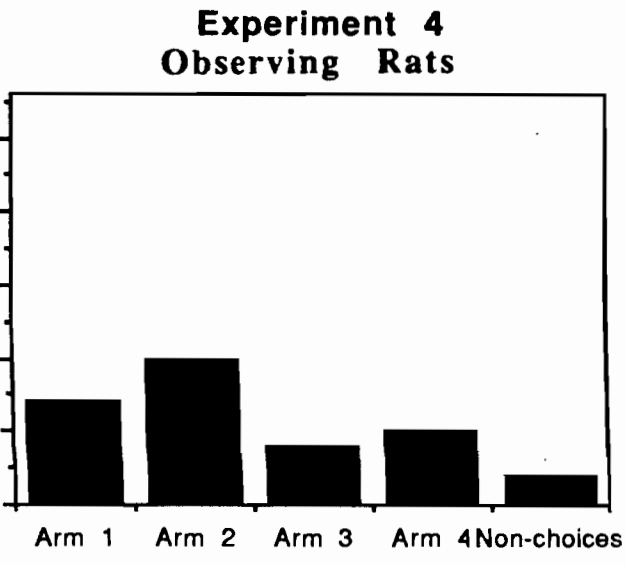


Figure 7-A
Number of Choices in Each Arm



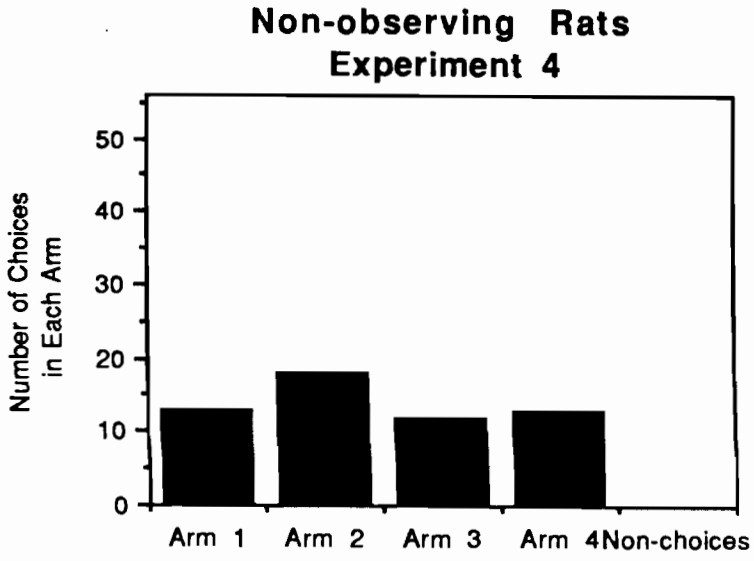


Figure 7-B
Number of Correct Choices in Each Arm