Effects of Reinforcement Schedules on Extinction Rate

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Abstract

The present experiment was conducted in order to determine the effects of type of reinforcement schedule on rate of extinction. The experiment involved 46 male Sprague Dawley rats. The subjects were housed in single hanging cages with wire-mesh floors. The rats were put on a food deprivation schedule. They were given a shaping procedure for 5 days, and then randomly assigned to one of five training groups. These groups included continuous reinforcement schedule (CR), fixed ratio 5 schedule (FR5), fixed ratio 10 schedule (FR10), variable ratio 5 schedule (VR5), and variable ratio 10 schedule (VR10). The day after training was completed, all rats were put through an extinction trial for 30 min. The number of lever presses made during the nine training trials was recorded, as well as the number of responses made during the 30-min extinction trial. Results showed that as the training trials progressed, the subjects made a greater number of responses per min. Type of reinforcement schedule also influenced the rate of responses throughout the experiment. However, the extinction trial did not significantly alter the number of lever presses made. These results may be due to the lack of sufficient time for significant extinction results to occur.
Effects of Reinforcement Schedules on Extinction Rate

In an experiment involving different schedules of reinforcement, if you stop delivering the reinforcement completely after the behavioral response, the response will decrease and ultimately result in extinction. Different reinforcement schedules include continuous reinforcement (CR), fixed ratio (FR), and variable ratio (VR). Under a CR schedule, the subject is presented with a reinforcer after every response. Under a FR schedule, the subject must perform a specific number of behaviors in order to receive the reinforcer. Commonly used FR schedules include FR5 and FR10. In these cases, the subject is required to show 5 or 10 responses, respectively, before getting reinforced. When using a VR schedule of reinforcement, the number of behaviors performed will vary before getting reinforced. For example, in a VR5 schedule, the subject will be required to respond an average of 5 times before getting reinforced.

Extinction occurs more rapidly after a CR schedule than after a VR or FR schedule. This effect is known as the partial reinforcement extinction effect (PREE), also called Humphrey’s paradox. The discrimination hypothesis states that in order for an animal to alter their behavior once the extinction trials begin, the animal must detect or discriminate a change in the reinforcement schedule. The schedule of reinforcement will directly effect how fast an animal detects a change, which will ultimately determine the rate of extinction of the behavior (Haggbloom, 1988).

Experimenters Jobe and Mellgren (1974) performed a study involving successive non-reinforcements (n-length) and resistance to extinction at spaced trials. The purpose of the study was to investigate the effects of number of non-reinforced trials prior to reinforcement (N-length) at spaced trials. They hypothesized that extinction performance should be a joint function of N-length and number of acquisition trials for those subjects experiencing the gray
goal box, but no differences should be observed for groups experiencing the striped goal box. In Experiment 1, subjects included 32 male albino rats of the Sprague-Dawley strain, purchased from the Holtzman Co. The rats were about 90 days old at the beginning of the experiment. They were house 2 per cage. Random assignment as used to assign the subjects to one of four experimental groups, and eight rats were in each group. Materials included a wooden straight-alley runway, divided into three sections (start, run, and goal). One goal box was painted flat gray and the other black and white vertical stripes. Both goal boxes were 38.1 cm long. A .01-sec Standard Electric timer was set off as soon as the first door was opened, and the timer was stopped as soon as the subject broke a photo-beam that was inside the goal box. The procedure involved the subjects to be put on a 12-g Purina Lab Chow food deprivation schedule. Water was easily accessible to them at all times of the experiment. One day before the pre-training began, subjects were marked and presented with a small amount of 45-mg Noyes food pellets in their home cage. On the day the experiment took place, the subjects were given two goal-box placements in the goal box with the bait. While in the home cage, they were given another small handful of Noyes pellets. Reinforcement consisted of six 45-mg Noyes pellets and non-reinforcement consisted of a 20-sec confinement in the un-baited goal box. Acquisition results showed that the goal-box main effect was significant, but neither the N-length main effect nor the Goal Box X N-Length interaction was significant. Extinction results showed a significant main effect for the goal-box. The authors interpreted their results by indicating that after 120 acquisition trials, a group that received an N-length of 1, 2, and 3 took longer to extinguish the behavior than a group that received an N-length of 3 in an alley with gray start, run, and goal sections. When the goal box was black and white striped, there was no differential resistance to
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extinction. The authors used an appropriate research design. They also used the correct and necessary statistical analyses.

In an experiment conducted by Capaldi, Nawrocki, Miller and Verry (1986), time between events as a retrieval cue was tested to see the effects on recall and the temporal similarity between the storage and retrieval intervals. The purpose of Experiment 1 was to determine if a memory stored at a long temporal interval would be better recalled at a long than at a short retrieval interval. The hypothesis was that where the storage interval is long, recall would be better than at a short retrieval interval. The subjects included 32 male rats, which were 78 days old when they arrived at the laboratory. The rats were bought from the Holtzman Company, located in Madison, Wisconsin. The apparatus included two adjacent runways, which were the same except for their color— one runway was black, and one was white. There were also two start boxes and two goal boxes. Lifting the brass start box door began a 0.01 s digital clock. When a photo beam was broken by the rat, the clock automatically stopped. After pre-training, all rats were randomly assigned to four different groups. The rats all received four trials each day terminating in 8, 0, 0, and 8 pellets, respectively. At the beginning of a trial, the rat was removed from its cage and placed into the start box. At this time, the start box door was lifted. The rat was given a maximum of 60 s to traverse the alley. If the subject did not reach the goal after 60 s passed, the subject was taken out of the alley and put into the goal box. After the rat finished eating all of the pellets on rewarded trials or after 15 s on non-rewarded trials, the rat was removed. The extinction trials took place on days 15-18. All rats received four trials each day terminating in 0 pellets. Results showed that Group NC ran fastest, Group BC next fastest, Group TC next fastest, and Group TC-BC slowest. It was found in Experiment 1 that if in
acquisition a change either in temporal interval or brightness occurred from Trial 3 to Trial 4, resistance to extinction occurred. The authors provided a good interpretation of the results.

Haggbloom (1988) conducted an experiment involving the signal-generated partial reinforcement effect. The purpose of the study was to distinguish between memory of the reinforcement event just experienced on a preceding trial, and a reinforcement event memory activated by a signal associated with the memory. Haggbloom hypothesized that this treatment would activate a memory of a non-reward, and that this signal-generated non-reward would become a signal for a reward much like event-generated does during conventional partial reinforcement training. The subjects of Experiment 1 included 30 male rats, that were purchased from the Holtzman Company. The rats were 90 days old at the beginning of the experiment. The apparatus included one straight alleyway. At the start of the alleyway there was a start box, and the end constituted a goal box. The boxes were separated from the rest of the runway by manually operated guillotine doors. Three clocks (0.01 s) recorded start, run, and goal times. Photoelectric circuitry controlled when it would be set off. Photoelectric circuitry was also responsible to operate the other two clocks. Inside the goal box was located a small block of wood with a 6-cm hole in it, serving as a goal cup. On the table adjacent to the start box sat a plywood pretrial feeding box. Ten rats were randomly assigned to one of three groups; Group Signal-N, Group Event-R, and Group CRF. After 15 days of food deprivation, Phase 1 began. Groups Signal-N and Event-R received three R trials and two N trials. All R trials in this phase were un-signaled, and all N trials were signaled. In Phase 1, over a period of 9 days, Groups Signal-N and Event-R experienced two different kinds of days. There were CRF days (odd number days) and continued discrimination training days (even numbered days). On CRF days, all groups received four consecutive R trials. Results showed that all groups ran slower on
signaled trials than on un-signaled trials. Experiment 1 demonstrated that a stimulus initially established as a signal for non-reinforcement, and subsequently presented on occasional reinforced trials in a separate phase of CRF training, increases resistance to extinction. The authors used an appropriate research design and performed the correct statistical analyses.

The purpose of the current study was to determine which type of reinforcement schedule (CR, FR5, FR10, VR5, or VR10) has a direct effect on how fast an animal detects a change in the reinforcement, which will determine the rate of extinction of the behavior. It was expected that extinction would occur more rapidly after a CR schedule than after a FR or VR, due to the PREE.

**Method**

**Subjects**

The subjects included 46 male Sprague Dawley rats (Ace Animals, Boyerstown, PA). The rat's individual weights ranged from 280-340g at the start of the experiment. Each subject was housed in single hanging cages with wire-mesh floors. The room in which they were housed was temperature controlled at 22 degrees C. The subjects were put on a 12 hr light/dark cycle, with lights on at 0700 hours and off at 1900 hours. They were given free access to water throughout the experiment, however they had restricted access to food (LabDiet Prolab Laboratory Animal Diet), as described in procedure section.

**Apparatus**

The apparatus included six operant conditioning chambers (Coulbourn Instruments, H10-11R-TC), each equipped with an internal lever (Coulbourn Instruments, H21-03R), an external lever, a pellet trough (Coulbourn Instruments, H14-01R), a pellet feeder (Coulbourn Instruments, H14-23R), and an internal light. The materials consisted of a chamber that was hooked up to an
environment connection board and Linc cable (Coulbourn Instruments, H03-04). The Linc cable was connected to the Habitest LabLinc (Coulbourn Instruments, H02-08), which ultimately delivered the data to a central computer running the data acquisition software Graphic State v2.01. Each chamber was housed in an experimental room, with dimensions measuring 2 m by 3 m. There was a computer, monitor and speakers, located on a table set against the wall opposite the door. The chamber was on the table placed next to the computer. The room also contained a desk and two chairs. While the experiment was running, the lights inside the room were shut off and the door was closed.

**Procedure**

Rats arrived in the lab and were given 7 days to acclimate before handling. Each rat was handled for 5 min per day for 4 consecutive days. During the handling period, rats were placed on a food deprivation schedule to get them to 85% of initial weights. Rats were then given a shaping procedure for 5 consecutive days. In this procedure, each rat was placed in the chamber when the light came on. The external lever was used to deliver food pellets after the rat performed a response. Responses included approaching the lever/spending time in right side of box, sniffing the lever/having head close to lever, touching the lever (eventually just with paws), and ultimately pressing the lever down on its own. After 30 min, the rat was removed from the box, put into its cage and the cage was covered. The rat was then returned to the animal room where it was given additional food to maintain its weight at 85% of its initial weight.

After 5 days of shaping, rats were then randomly assigned to one of five groups (continuous reinforcement schedule, fixed ratio 5 schedule, fixed ratio 10 schedule, variable ratio 5 schedule, and variable ratio 10 schedule). They were trained for 5 consecutive days on assigned schedule for 30 min each day. The process for a typical training day included weighing
the rat and recording its weight. The rat was then brought in its covered cage into its assigned experimental room. When the light in the chamber came on, the rat was placed inside the box. According to its type of reinforcement schedule, the rat was reinforced for one of the following behaviors: pressing the lever either 1 time, 5 times, 10 times, on average 5 times or on average 10 times. The experimenter was responsible for observing and taking notes on the rat’s specific behavior and habits. After 30 min, the rat was taken out of the chamber and put into its cage. The cage was covered and brought back to the animal room. There, it was given additional food to maintain its weight at 85% of its initial weight, after adding 50 g. The rats were then given 2 days of rest before given 4 more days of training on their assigned schedule for 30 min each day. On the day following the last day of training, all rats were put through an extinction trial for 30 min. In the extinction trial, when the rat was placed in the chamber, it was not reinforced for the trained behavior. The rat’s specific behavior and reaction was observed and noted by the experimenter. The number of lever presses made during the nine training trials was recorded, as well as the number of responses made during the 30-min extinction trial.

Results

The statistical analysis used for the 9 training trials data was a 5 × 9 (Schedule Type × Training Trial) mixed ANOVA. The results of this ANOVA showed that there was a significant main effect of training trials, $F(1, 41) = 161.186, p < .05, \eta^2 = .797$. The main effect of reinforcement schedule was also found to be significant, $F(4, 41) = 8.242, p < .05, \eta^2 = .446$. The ANOVA also presented that the interaction effect between training trials and reinforcement schedule was significant, $F(4, 41) = 19, p < .05, \eta^2 = .650$. Figure 1 illustrates the influence of the 9 training trials on the response rate (Response/min) for each group.
The statistical analysis used for the extinction trial data was a one-way independent groups ANOVA. The results of the ANOVA on the extinction trial data showed that there was no significant effect of the extinction trial on number of responses made, $F(4,41) = 1.576, p > .05$. Figure 2 illustrates the influence of the extinction trial on the response rate for each group.

A Tukey post hoc test on the reinforcement schedules for the training trials showed there was a significant difference between CR ($M = 6.78$) and FR5 ($M = 19.85$), FR10 ($M = 24.88$), and VR10 ($M = 26.30$). The difference between CR and VR5 ($M = 17.80$) was found to be insignificant. The post hoc tests also presented that there was an insignificant difference between FR5 and both FR10 and VR10. The difference between FR10 and VR5 was also found to be insignificant. In addition, there was no significant difference between FR10 and VR10 as well as VR5 and VR10.

**Discussion**

The experiment showed no significant effect of extinction trial on number of responses made. However, there was a significant increase of response rate as the training trials progressed. The type of reinforcement schedule that the subject was exposed to also had a significant effect on their response rate. Subjects with a CR schedule had a significantly lower response rate throughout the 9 training trials than those with FR5, FR10, and VR10 schedules.

These results suggest that as the subjects become accustomed to their particular training schedule, their responses become faster and more immediate. The subjects tend to learn that the more responses it shows the more reinforcers it receives. The subjects form pair-wise associations between all three components of the stimulus-response learning situation. They pair a stimulus with a response, a response with a reinforcer, and ultimately the stimulus with the reinforcer. This knowledge leads to an increased response rate. When the reinforcer is no longer
delivered after the behavioral response, response will decrease and end with extinction of the behavior. However, in order for extinction to occur, the animal must discriminate a change in the reinforcement schedule. In this experiment, the subjects did not discriminate a change and therefore did not extinguish their behavior.

The previously mentioned research indicated that when subjects are consistently presented with a reinforcer after a specific response, their response rate will increase. When the subjects are not given a reinforcer for a response that they have learned through a consistent reinforcement schedule, their response rate will decrease until they ultimately extinguish the behavior completely.

Because the rats were put through only one 30 min extinction trial, the insignificant results may be due to the lack of sufficient time. The subjects may have simply needed more time to extinguish the behavior. Since the training trials were prolonged to 9 trials, the subjects learned their reinforcement schedule very precisely and mastered their response techniques. By allowing only 30 min to extinguish their learned behavior, it may not be providing enough time for the rat to detect or discriminate a change in the reinforcement schedule. Therefore, until this detection has occurred, the rat should not be expected to significantly alter their behavior. The increase in responses throughout the 9 training trials could have been due to the subject’s weight loss. They may have been more determined or eager to press the lever numerous times in order to receive the reinforcer since they were at an uncomfortable or unhealthy weight.

This experiment lacked an equal number of subjects in each group. There were 15 subjects in the CR group, 8 in the FR5, 8 in the FR10, 7 in the VR5 and 8 in the VR10. By having an uneven number of subjects in each group, it may have swayed the means and caused the results to be less accurate overall. The food deprivation schedule was also difficult to
control. At many times during the experiment, numerous subjects were either above or below their goal weight. This may have had an effect on their response rate due to lack of energy (if they were underweight) or lack of interest/motivation to receive the food reinforcer (if they were overweight). In some cases during the experiment, the device that was responsible for delivering the reinforcer would not function properly because it was jammed. In turn, the subject would not be reinforced for its response automatically. This occurrence may have caused a temporary change in response rate for some subjects. Another limitation of the experiment that could have affected the results is the fact that not every rat was trained at the same time of day. Although each particular rat was consistently trained at the same time each day, the overall time differences between the rats training times present that their response rates have potential to be different due to lack of sleep or less exposure to light before the start of the experiment.

Overall, this study showed that when subjects are trained to follow specific reinforcement schedules, their response rate increases over time. When the extinction trial took place, results showed that there was relatively no difference in response rate. This particular finding presents another possible area of research. It would be interesting to further the study and see if the subjects would extinguish the behavior if the trial continued for a longer span of time. The current results show merely their automatic, initial response to the lack of reinforcement. Over a prolonged time frame, their behavior and response rate may change more dramatically and significantly. The research also clearly illustrated that the type of reinforcement schedule significantly affected the number of responses made. By altering the subject’s schedule of reinforcement, their response rate will change accordingly. Each schedule of reinforcement goes along with a specific, predictable pattern of behavior. By manipulating the schedule of reinforcement, the experimenter is able to generally control the way the subject responds. The
results of the 9 training trials showed a steady increase in response rate. The longer the subject is exposed to the training, the faster their response rates will become. This same pattern goes along with numerous different behaviors in everyday life. The more exposure and experience a person or animal has at a certain behavior with a reinforcer following, the more proficient they will become. However, when a reinforcer is no longer paired with the behavior, the person or animal is less likely to continue the behavior.


Figure 1. An illustration of the response rate (response per minute) for each group over the 9 training trials. Results showed that as the trials progressed, the number of responses per min increased. As the subjects grew more familiar with the concept of pressing the lever and receiving a reinforcer, most groups increased their response rate with each trial. However, subjects that were on a CR schedule were generally consistent in their number of responses per min throughout the 9 training trials.
Figure 2. An illustration of the response rate for each group during the extinction trial. Results showed that the extinction trial did not have a significant effect the rate of responses made. When the subjects were put through the extinction trial and received no reinforcement for their responses, most groups did not significantly change their behavior. However, subjects in the FR1 group showed an increased response rate.