

## **Partial reinforcement learning and its extinction in the turtle, *Geoclemys reevesii***

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Three groups of nine turtles each were trained in a straight alleyway followed by extinction of the learned response to assess the partial reinforcement extinction effect (RRE). Group CR was trained under 100% continuous reinforcement, and Group Rd (random alternation) and Group SA (single alternation) were trained under 50 % partial reinforcement. Significant differences were found at the last day of extinction. Group CR was less resistant than the other two partial groups (i.e., a PRE was demonstrated), which did not differ from each other. The results were discussed in terms of the phyletic difference in learning ability.

### **I. Introduction**

The partial reinforcement extinction effect (PRE) refers to the phenomenon that an animal group given partial reinforcement is more resistant to extinction than that given continuous reinforcement.

A number of studies have been conducted by using rats as the subjects, and several influential theories have been proposed on the basis of the results from rat-experiment. There is another line of approach, a comparative one, which investigates a PRE from a phylogenetic viewpoint employing diverse animals such as mammals, birds, reptiles, fish and invertebrate animals. A major concern of this approach is whether or not a PRE occurs in a particular species. The approach aims to estimate the learning ability or intelligence common to all members of a class from many psychological facts including PRE rather than estimate the ability of a particular species. In general, the PRE was found in the mammals and birds, but was not found in fish and the animals below fish.

However, in the case of reptiles, in which turtles have been used typically as the subjects, a PRE was obtained in some studies (Murillo et al. [8], Wise & Gallagher [10]), but not in other studies (Eskin & Bitterman [3], Gonzalez & Bitterman [4]), although there are very few studies which used turtles in the PRE experiments. Since contradicting results have been reported on the occurrence of PRE itself, the turtles often said to be a boundary species which links the mammals or birds and the fish viewed from the evolution of intelligence.

Previous two studies which found a PRE, however, compared only one partial reinforcement group with continuous reinforcement group. If various partial reinforcement groups were arranged in this situation, further informations about learning ability of turtles would be obtained on the basis of the difference in resistance to extinction among groups.

Thus, in the present experiment, two partial reinforcement groups (random and single alternations) and a continuous reinforcement group were formed to investigate the PRE in the turtles. All groups were trained and extinguished in a straight alleyway.

## II. Method

### Subjects

The subjects were 27 turtles, *Geoclemys reevesii*, purchased locally. They were about two years old, and about 13 cm long and 7 cm wide. They were maintained in individual tanks. Each tank (home tank), 24 cm long, 39 cm wide and 27 cm high, was made of transparent plastic board. The water was changed daily and was maintained at a depth of around 6 cm. The bottom of a tank was covered with pebbles at a depth of approximately 2 cm, and a 12 × 10 × 6 cm brick was placed in the corner of the bottom to allow the turtle to land on.

### Apparatus

A straight alleyway, which was made of poliviny-chloride board, was 105 cm long and 9 cm wide enclosed by walls 20 cm high. Manually operated guillotine doors separated the alleyway into three different compartments. It consisted of a 20 cm start box, a 65 cm runway and a 20 cm goal box. A goal box was painted light gray and the other sections were painted dark gray. A trough-like pellet feeder, which was 10 cm long, was attached to the back of the opposite wall of the goal box at an angle of 45°. Reward pellets were given to the subject from the small hole which was located 16 cm from the bottom. The experimental apparatus was filled with water of 7 cm in depth.

### Procedure

(1) *Habituation training* Two months before the preliminary training began, the turtles were sunned and handled frequently during habituation training. For the first half of this period, food pellets were given to the subjects as much as they can eat. The number of pellets was reduced gradually day by day for the next half of this period. At the end of habituation training, only eight pellets were given daily. This food ration was maintained till the end of experiment.

(2) *Preliminary training* Following two months of habituation training, the subjects received the preliminary training for two weeks. During this period, the subjects were handled daily and allowed to explore the inside of the apparatus for five min a day. From Day 11 to Day 14, two reinforced trials per a day were given to the subjects. In these trials, each subject was introduced into the start box and was required to traverse the alleyway in order to obtain one 15-mg pellet at the goal box.

(3) *Experimental training* On Day 15, the first day of acquisition training, the subjects were divided randomly into three groups of nine turtles each and assigned to each of three reinforcement schedules (CR, Rd and SA). In acquisition, eight trials were given daily for ten days (for a total of 80 trials). Group CR received continuous reinforcement. The other two groups received 50 % partial reinforcement. Group SA received the sequence of reinforced (R) and non-reinforced (N) trials, RNRNRNRN every day. In Group Rd, the sequences of RNRNRNRN, NRNRNRNR were repeated every two days. A trial started by pulling up the first guillotine door and terminated when the turtle entered throughly into the goal box. Upon entering into the goal box the second guillotine door was lowered. On R trials one pellet was ejected through the feeding trough. On N trials (also during extinction trials) the subject was detained there for 30

sec. The intertrial interval was about a min.

On Day 25 began extinction training. In this period, the subjects received eight trials daily for five days (for a total of 40 trials). If the turtle failed to enter the goal box within 120 sec, it was guided gently to the goal box and assigned a time score of 120 sec.

Daily food, which consisted of eight pellets minus the amount eaten in the apparatus, was provided at least 30 min after the last trial of the day during the acquisition and extinction periods.

### III. Results

Six subjects were removed because of illness. A total of 21 turtles were available for the analyses. Response times were converted into logarithms.

#### Acquisition

The mean times for three groups are shown in **Figure 1**. An analysis of variance on the log mean times for three groups (each  $N=7$ ) indicated that there was a significant days effect [ $F(9,162) = 9.35, p < .01$ ], but that the groups effect and the groups  $\times$  days interaction were not significant. An analysis of variance on the means of the last day of acquisition (terminal level) showed that the group difference approached the significant level [ $F(2,180) = 2.83, p < .10$ ]. Tukey's posttests indicated that Group Rd ran significantly slower than the other two groups. **Figure 2** shows mean running times on reinforced (R) and nonreinforced (N) trials for two groups. As can be seen from this figure, Group SA and Rd did not run differentially between the times on R and N trials. An analysis of variance on each of groups showed similar results, that is, only days effect was significant [ $F(4,54) = 4.28$  and  $2.63$  for Groups SA and Rd, respectively,  $ps < .05$ ], but the type of trial effect and the interaction of groups  $\times$  type of trial were not significant. Tukey's posttests revealed no significant difference between the times on R and N trials on each of acquisition days for both SA and Rd groups.

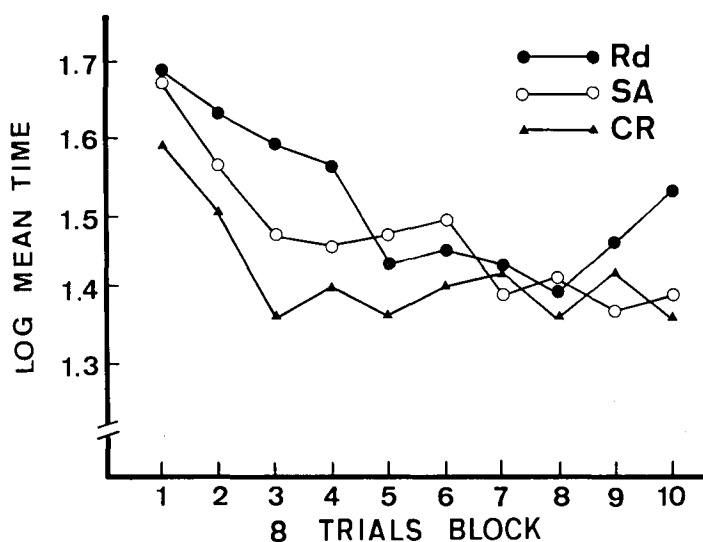


Fig. 1. Running time for three groups on each of the 10 acquisition days.

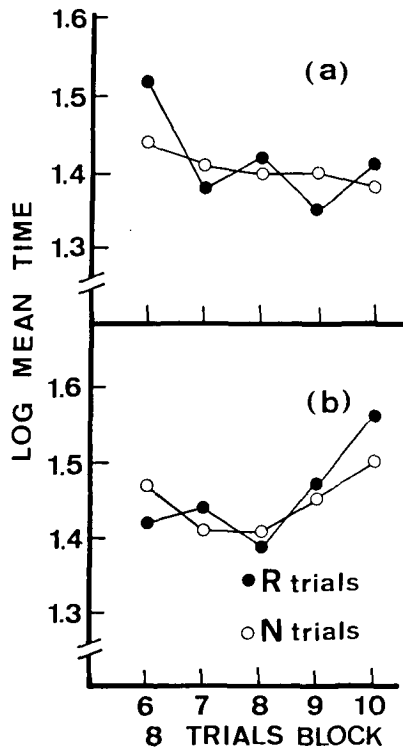


Fig. 2. Running time on reinforced (R) and nonreinforced (N) trials for each of SA (a) and Rd (b) groups over the last five days of acquisition.

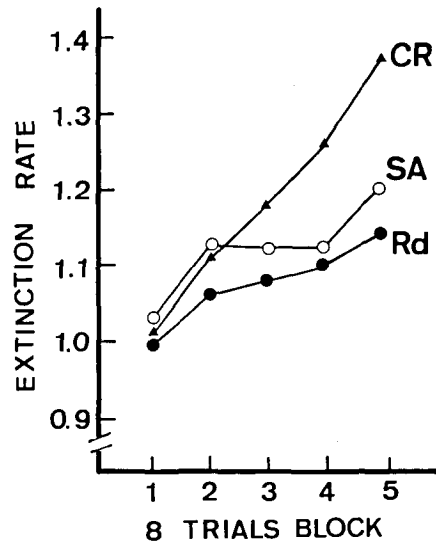


Fig. 3. Extinction rate for three groups on each of the 5 extinction days.

### Extinction

An analysis of variance on the mean times indicated that only days effect was significant [ $F(4,72) = 15.33, p < .01$ ], but the groups effect and the groups  $\times$  days interaction were not significant. Tukey's posttests revealed that there was no significant group difference on each of extinction days.

At the terminal acquisition level, however, there were innegligible differences among three groups though not significant. To assess extinction performance, the time scores were transformed into rate measures, as recommended by Anderson [1]. The transformations employed here was, however, rather simple than that originally proposed by Anderson. The transformation corrected for different times at the end of acquisition. The mean time on all trials on the last day of acquisition was used to estimate the asymptote of acquisition. Each extinction score was corrected with the equation: rate corrected time = extinction trial / asymptote of acquisition. Individual animal's transformed rates were averaged within group and plotted in Figure 3.

Analysis of variance on the rate measures indicated that the days effect was significant [ $F(4,72) = 15.90, p < .01$ ], and that the groups  $\times$  days interaction approaches the significant level [ $F(8,72) = 1.90, p < .10$ ] though the groups effect was not significant. The interaction of

two factors reflects faster extinction of Group CR than the other two groups, as can be seen from Figure 3. Tukey's posttests indicated that on Day 5 of extinction Group CR was significantly less resistant than the other two groups, which did not differ from each other.

#### IV. Discussion

The present experiment provides evidence of a PRE in turtles. The result agrees with those of previous studies which found a PRE using a straight alleyway (Murillo et al. [8]) and a black-white discrimination problem (Wise & Gallagher [10]). Thus, the occurrence of PRE seems to be independent of a particular experimental task. In addition, it is worth noting that the present study used almost the same species as one used in the study of Gonzalez & Bitterman [4], which failed to find a PRE. Species in both of studies belong to a genus *Clemmys*, in contrast to that the animals used in the other studies ([3], [8], [10]) belong to a genus *Pseudemys*. Again, it is apparent that the PRE can be demonstrated for turtles in both genera.

Certain difference between the two studies which did not show PREs, Eskin & Bitterman [3] and Gonzalez & Bitterman [4], and the two which demonstrated PREs, Murillo et al. [8] and the present study, should be pointed out. In the former studies, trials were widely spaced (1 trial per day), while in the latter studies trials were massed (6 to 8 trials per a day, 30 sec to 1 min intertrial interval). This procedural difference might have contributed to the discrepancy in findings.

In the present experiment, there was not a significant difference between Groups SA and Rd in terms of resistance to extinction. More recently, similar results were reported by Ishida & Nakata [7] employing a simple discrimination task. They found no difference between SA and Rd groups on resistance to extinction though they demonstrated a clear-cut PRE. Under almost the same reinforcement conditions, however, the rat experiments often demonstrated that a group given Rd schedule was more resistant to extinction than that given SA schedule (e.g., [9], [2], [5], [6]). The difference between results from two species might indicate that turtles, unlike rats, can hardly learn (or discriminate) the difference between patterns of partial reinforcement though they distinguish partial reinforcement from continuous reinforcement. Therefore, reptiles still can be said to be a boundary species from the viewpoint of the evolution of learning capacity.

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### クサガメの部分強化学習とその消去

(石田雅人・北村 豪)

部分強化消去効果(PRE)を検討するために、1群9匹からなる3群のカメを直線型走路で訓練し、つづいて学習された反応を消去した。CR群は100%の連続強化を受け、Rd(ランダム交替)とSA(単一交替)の両群は50%の部分強化を受けた。有意な差は消去の最終日で見いだされた。CR群は両部分強化群よりも消去抵抗が低かった(つまりPREが実証された)。ただし両部分強化群間には差がなかった。これらの結果について、学習能力における系統発生差の観点から考察した。