Title	Aftereffect of reinforcement on redundant response in wister rats : a preliminary investigation
Sub Title	
Author	八賀, 洋介(Hachiga, Yosuke)
Publisher	Centre for Advanced Research on Logic and Sensibility The Global Centers of Excellence Program, Keio University
Publication year	2011
Jtitle	CARLS series of advanced study of logic and sensibility Vol.4, (2010.) ,p.107- 112
JaLC DOI	
Abstract	
Notes	Part 1: Brain and Evolution
Genre	Research Paper
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=KO12002001-20110331-0107

12 Aftereffect of Reinforcement on Redundant Response in Wister Rats: A Preliminary Investigation

Yosuke Hachiga[1]

[1] Centre for Advanced Research on Logic and Sensibility (CARLS), Keio University

I. Introduction

The past several decades have seen experimental psychologists studying similar categories of impulsive behavior. Madden and Johnson (2010) classified them into three categories, that is, (1) failure of attention, (2) inability to inhibit prepotent responses, and (3) the failure of delayed or probabilistic events to control or influence current choices. Whereas pharmacological research is common in category 2, behavioral research focused chiefly on category 3. The behaviorists were particularly interested in the value of reinforcement, which was discounting by delay or made uncertain by probabilistic contingencies on delivery of the reinforcement.

The behavioral experiment reported here presents a phenomenon concerning category 2, the response-inhibition form of impulsivity. The procedure was simple discrimination training. In an operant chamber that had two levers and two stimulus lights above the levers, subjects underwent a variable ratio (VR) schedule. The schedule functioned only for a lever above which a corresponding stimulus light turned on. Which light would turn on was determined randomly in each trial. So subjects were repeatedly asked to discriminate which lever would function at the moment, even though there was no pattern to the activations (except as revealed by the lights). Although generally they succeeded in this discrimination training, all of them showed a similar error pattern. This report discusses this finding in terms of the value of the reinforcement.

II. Method

1. Subjects

Eight naive male Wister rats were maintained at approximately 80% of their free-feeding body weights. At the beginning of the training, they were 36 weeks old. Water and sawdust were continuously available in their home cages, where a 12-hour light-dark cycle was in effect.

2. Apparatus

The experimental chamber, sized 210 mm in length by 280 mm in width by 270 mm in height, was enclosed in a sound-dampening box. The chamber had a ceiling and side walls constructed of Plexiglas, and front and back walls of metal. The front wall contained two shielded stimulus lights (white 28-v bulbs), 120 mm above the floor and 100 mm apart. Two response levers, requiring a force of 0.15 N to operate, were located 70 mm above the floor and 80 mm apart measured center to center. A pellet tray that received 45-mg food pellets was centered between the levers 20 mm above the floor. A shielded houselight (28-v bulb) was on top of the back wall. A speaker for presenting white noise and a ventilating fan were attached to the outer box. All experimental devices were controlled by a computer using Visual Basic 2005 Express Edition software.

3. Procedure

After all subjects were trained in lever-pressing, a discriminable VR schedule was begun. In the schedule, at the beginning of a trial, one of the stimulus lights turned on. Only the lever positioned on the same side as the illuminated light functioned in this trial. Subjects could press the other lever, but that lever never produced reinforcers. A trial ended by presentation of the reinforcer for the response to the selected lever.

The average ratio value increased from 1 to 20 as the training proceeded. In VR20, 12 VR values were used: namely, 1, 3, 5, 7, 9, 12, 16, 20, 25, 32, 42, and 70 (see Fleshler & Hoffman, 1962).

A session consisted of 100 trials performed or 60 min elapsed, whichever occurred first. The training ended when an animal's performance stabilized and it had acquired the discrimination. Subjects' VR training ranged from 35 to 55 sessions. For all subjects, VR20 was performed for the last 17 sessions or more.

III. Result

Figure 1 shows the learning curve of discrimination training in each subject. Data from all sessions was used; each session was divided into eight units as shown along the X axis. The solid line shows the average for each unit across all subjects. On the whole, as training progressed, all subjects developed, above the chance level, the ability to discriminate the difference between the stimulus lights being on and off.

During the experimental procedure, after any given trial in which a particular light was lit (let us call it light A), the next trial might light the same light (A), or it might light the other light (B).

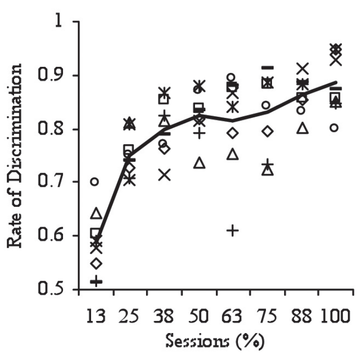

Figure 1. Learning curve showing that subjects can discriminate the stimulus lights. Each type of symbol indicates one subject. The solid line is the average. Legend in Figure 2.

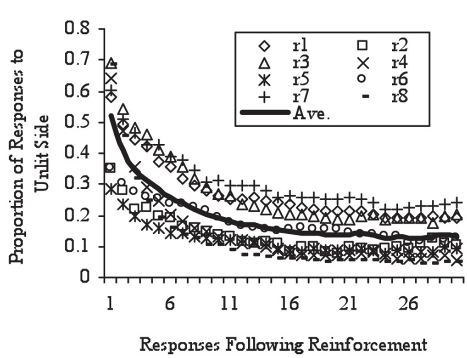

Figure 2. Proportion of redundant responses in last 20 sessions, showing the range from the first to the thirtieth response after reinforcement. Each type of symbol indicates one subject. The solid line is the average.

In this situation, all subjects frequently made the mistake of pressing the lever associated with the light in the previous trial (A), instead of changing immediately to press the lever corresponding to the light that was lit in the current trial (B). Figure 2 shows the proportion of such redundant (incorrectly continuing) responses in the last 20 sessions. The figure also omits the responses emitted within 1000 ms of the presentation of the reinforcement; this removes the possibility of confusing reinforcement delivery with bout responses. The figure shows that all subjects sometimes emitted a response using the lever on the side of the unlit light when that side had been lit on the preceding trial. As the response lag from the last reinforcement increased, the redundant responses decreased.

This decay curve embodies the value of reinforcement represented by the discounting function. Therefore, nonlinear regression was used to fit both a hyperbolic decay function, as in Equation 1, and an exponential function, as in Equation 2, to the observed data.

$$V=\frac{A}{1+kL} \tag{1}$$

$$V=Ae^{-kL} \tag{2}$$

In both equations, V is the value of the reinforcement that preceded responses, A is the amount of reinforcement, L is the response lag from presentation of the reinforcement, and k is a free parameter. In Equation 2, e is Euler’s number (approximately 2.718). Table 1 shows r^2 and the best-fit k for each subject. The hyperbolic function provided a better fit (higher r^2) for every subject, and for the average data. Figure 3 shows both functions and the average data for all individuals. As response lag increased, the observed data fell slightly above the values calculated according to the (better-fitting) hyperbolic curve.

IV. Discussion

All subjects discriminated the function of the lights under this procedure. However, all of the subjects showed a similar error pattern. After delivery of reinforcement due to a correct response, they were likely to respond by pressing the lever on the same side as the last functioning lever, despite the fact that they should have been able to infer that that lever wouldn’t function in the next trial (when the tell-tale illumination of the other light so indicated).

Table 1. r^2 for the hyperbolic and exponential models of discounting, estimated k-values in each subject, and average data

	Hyperbolic		Exponential	
Sub.No.	r^2	k	r^2	k
1	0.938	0.274	0.766	0.123
2	0.875	0.908	0.651	0.492
3	0.934	0.260	0.754	0.120
4	0.980	0.611	0.801	0.275
5	0.892	1.206	0.583	0.734
6	0.906	0.614	0.715	0.314
7	0.914	0.219	0.752	0.100
8	0.973	0.727	0.763	0.325
Average	0.949	0.482	0.728	0.224

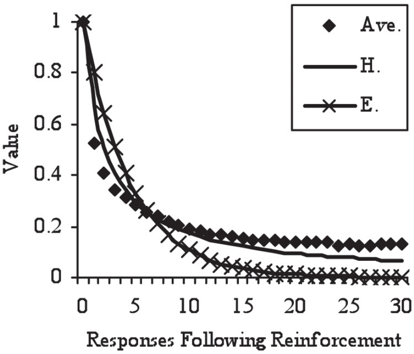

Figure 3. Discounting decay function for both hyperbolic (H) and exponential (E) models, and the observed average data.

This response curve was best fit by a hyperbolic function. This phenomenon can be considered to be a kind of delayed discounting, but it would be more accurate to call it response lag discounting. Certainly, reinforcement affected the occurrence of redundant responses. If it were, it connects inability to inhibit prepotent responses with discounting function. And just as in previous studies of delayed discounting (see Madden and Johnson, 2010), a hyperbolic function fit the data better than an exponential function did.

Here the value of past reinforcement, however, may not be the only factor affecting the redundant responses. This may be because the proportion of redundant responses was higher (as the response lags increased) than values predicted from the discounting function. Why did the redundant responses occur? From the standpoint of maximizing the obtained reinforcement under this schedule, redundant responses were just redundant. From an alternative standpoint, as lags increased, subjects seemed to use a strategy of increasing behavioral variability.

Behavioral variability has survival value because it increases susceptibility to selection by reinforcement, in particular when the environment is variable (even unpredictable) and may change at any moment. Possibly, redundant responses indicate that subjects have adequately adapted to the environment set by the discriminable VR schedule, and are checking (from time to time) to see if the environment will change again. It might not, in the long run, be wise to commit oneself to the goal of completely satisfying one's environment. Whether such behavior embodies a strategic optimization of some sort is a hypothesis to be analyzed and discussed cautiously in future research.

References

Fleshler, M., & Hoffman, H. S. (1962). A progression for generating variable-interval schedules. *Journal of the Experimental Analysis of Behavior*, *5*, 529–530.

Madden, G. J., & Johnson, P. S. (2010). A delay-discounting primer. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: the behavioral and neurological science of discounting*. United Book Press, Baltmore, MD.