7 Self-control and Impulsive Choices in Different Choice-Earning Dependencies

Taku Ishii[1]

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

I. Introduction

Animals' self-control and impulsive behavior has been studied in a situation where they can choose between a later-larger reinforcer and a sooner-smaller one (Green and Myerson, 1993; Logue, 1988; Rachlin, 1974). The most important determinants of their choice in this situation are the magnitude of and the delay to upcoming reinforcers. A larger reinforcer can be less effective than a smaller one when it can be obtained only after a relatively long delay.

This impact of the delay to a reinforcer has been known as "delay discounting" and studied with an adjusting-delay procedure. This procedure repeatedly offers an animal two alternatives; that is, standard and adjusting alternatives. For example, if a rat or a pigeon chooses the standard alternative, it obtains one food pellet after 2 s: on the other hand, if it chooses the adjusting alternative, it obtains three food pellets after a certain delay that is shortened when the standard alternative is preferred and lengthened when the adjusting alternative is preferred. Therefore, it is when the delay of the adjusting alternative makes 3 food pellets equally effective as one food pellet obtained after 2 s that an animal chooses the two alternatives equally often.

Mazur (1987) used the adjusting-delay procedure to identify a delay-discounting function. He obtained sets of delays that made two different magnitudes of reinforcers equally effective. He then plotted the sets of delays and showed that an indifference function derived from a hyperbolic function describes the plots better than ones derived from an exponential or a reciprocal function. This result indicates that the way in which a delay discounts effectiveness of a reinforcer conforms to a hyperbolic function, which plays a major role in theories of self-control and impulsive behavior (e.g., Ainslie, 2001).

While the use of the adjusting-delay procedure and the identification of a delay-discounting function revealed that a delay to an upcoming reinforcer strongly controls self-control and impulsive behavior, effects of broader contexts of a choice situation have been relatively unknown. An exception is the study by Hastjarjo and Silberberg (1992). They found that the preference for a later-larger reinforcer was enhanced when the number of choice opportunities in an experimental session was reduced. This finding indicates that broader foraging context, how much food an animal can earn in a session, influences self-control and impulsive behavior.

The purpose of the present experiment is to further investigate effects of choice context. Past studies, including Hastjarjo and Silberberg (1992), used the choice context in which an animal could maximize the amount of food (or other kinds of reinforcers) earned in a session if it chose a later-larger reinforcer exclusively. This context itself could enhance the preference for a self-control alternative. Therefore, the present experiment compared the traditional choice context with a context in which the amount of food earned in a session is determined independently from animals' choice.

II. Method

1. Subjects

Four experimentally-naive pigeons and two experienced pigeons served as subjects. They were housed in individual cages, where water and grit were always available, and maintained at approximately 80% of their free-feeding weights, with supplementary food (mixed grain) provided after experimental sessions when needed.

2. Apparatus

Three standard operant chambers, 24-cm deep × 30-cm wide × 29-cm high, were used. Each chamber had three response keys on the front wall, 22 cm above the grid floor. The keys were 2 cm in diameter, 8.5 cm apart from each other (center to center), and could be transilluminated by a white light. Responses on an illuminated key produced an audible click made by a relay; responses on a dark key did not. In two of the chambers, a food hopper was located below the center key; in the other, a pellet receptacle, to which a pellet dispenser delivered food pellets, was located below the center key. When food was provided, the aperture of the food hopper or the pellet receptacle was illuminated by a white light. A houselight on the rear wall provided general illumination. Each chamber was enclosed in a sound-attenuating box containing a ventilation fan. Continuous white noise masked extraneous noises. Event scheduling and data recording were controlled with a MEDSTATE NOTATION™ program and a MED-PC™ system interfaced to an IBM-compatible computer.

3. Procedure

3.1. Shaping

Pigeons' key-pecking responses on the left, center, and right white keys were autoshaped with a modified autoshaping procedure. In this procedure, one key that was randomly selected from the three keys was illuminated with a white light at the beginning of a trial. After 8 s had elapsed without a response on the key, 4-s access to the food hopper or two pellets (dependently on the chambers) were provided, and then an intertrial interval started. If pigeons pecked on an illuminated key, the food presentation and the intertrial interval followed the key-pecking response immediately. The duration of the intertrial interval was 45 s on average, during which only the houselight was lit. An experimental session consisted of 60 trials.

After key-pecking responses were successfully shaped, the responses were reinforced with a fixed-ratio one schedule. In this schedule, a key-pecking response on one key that was randomly selected from the three keys after each reinforcer produced the food presentation. No intertrial interval was used in this schedule. A session ended with 60 food presentations. This procedure was used for five sessions.

3.2. An adjusting-delay procedure

An adjusting-delay procedure was initiated just after shaping and maintaining key-pecking responses. A trial in this procedure started with the illumination of the center key and the houselight. A peck on the center key turned it off and turned on the side keys. The left key was a standard alternative: A peck on it started a 2-s delay period followed by the presentation of a smaller amount of food (2-s access to food provided by the food hopper or one pellet). On the other hand, the right key was an adjusting alternative: A peck on it started a delay period, the duration of which was adjusted dependently on pigeons' choices (see below), followed by the presentation of a larger amount of food (6-s access to food provided by the food hopper or three pellets). The presentation of food was followed by an intertrial interval, during which all the lights in the chamber were turned off. The duration of an interval was adjusted so that the interval between the onsets of trials was 40 s. In the case that pigeons did not peck any of the illuminated keys within 10 s after the onset of the white lights, all the lights in the chamber were turned off, and an intertrial interval started, after which the same trial as the cancelled one restarted.

Twelve successive trials composed a block. The first two trials in a block were forced-choice trials, in which only one of the two alternatives was presented after the peck of the center key. Each of the standard and the adjusting alternatives was presented once in the two forced-choice trials with a randomized order. The last 10 trials in a block were free-choice trials as described in the above paragraph. If pigeons chose the adjusting alternative seven times or more in the 10 free-choice trials, the delay-to-food period of this alternative was lengthened by 10% in a next 12-trial block: if they chose the adjusting alternative three times or less, the delay was shortened by 10%: otherwise, the duration of the delay was unchanged. At the start of this procedure, the adjusting delay was set at 2 s. Thereafter, the adjusting delay that resulted from the last trial in a session determined the one in the first block in the next session.

3.3. Choice-earning dependencies

The rules of the termination of a session defined two conditions. In a choice-dependent condition, a session ended with the termination of the fifth 12-trial block. In this condition, the number of choice opportunities could be regarded as the income that pigeons spent to earn food, and the amount of food earned in a session was dependent on pigeons' choices. In a choice-independent condition, on the other hand, a session ended when the consecutive amount of food presented in a session exceeded a certain amount: that is, consecutive 240-s activation of the food hopper or totally 120 pellets. These amounts corresponded with the amount of food that would be earned if pigeons chose the standard and the adjusting alternatives evenly in the choice-dependent condition. Therefore, in the choice-independent condition, the number of choice opportunities varied dependently on pigeons' choices, and the amount of food earned in a session was largely independent from their choices (the amount could vary from 240- to 244-s activation of food hopper or from 120 to 122 pellets).

Three of the six pigeons, named A13, E12, and G33, were assigned to the choice-dependent condition, and the others, named E31, F31, and H13, to the choice-independent condition. E12 and E31 were assigned to the chamber with the pellet dispenser, and the others to the chambers with the food hopper.

III. Results

The adjusting delays for all the pigeons have not yet stabilized at indifference points. Therefore, Fig. 1 shows the transitions of the adjusting delays in each block from the beginning of the present experiment to the latest session. The open symbols indicate data from the choice-dependent condition and the filled symbols those from the choice-independent condition. The adjusting delays for E12 and E31 (the upper panel of Fig. 1), which were assigned to the chamber with the pellet dispenser, changed within the almost same range; that is, from 2 to 15s. (Note that the ordinates in Fig. 1 have logarithmic scales.) However, among the adjusting delays for the pigeons assigned to the chamber with the food hopper, those from the choice-independent condition drifted around higher levels than those from the choice-dependent condition, which

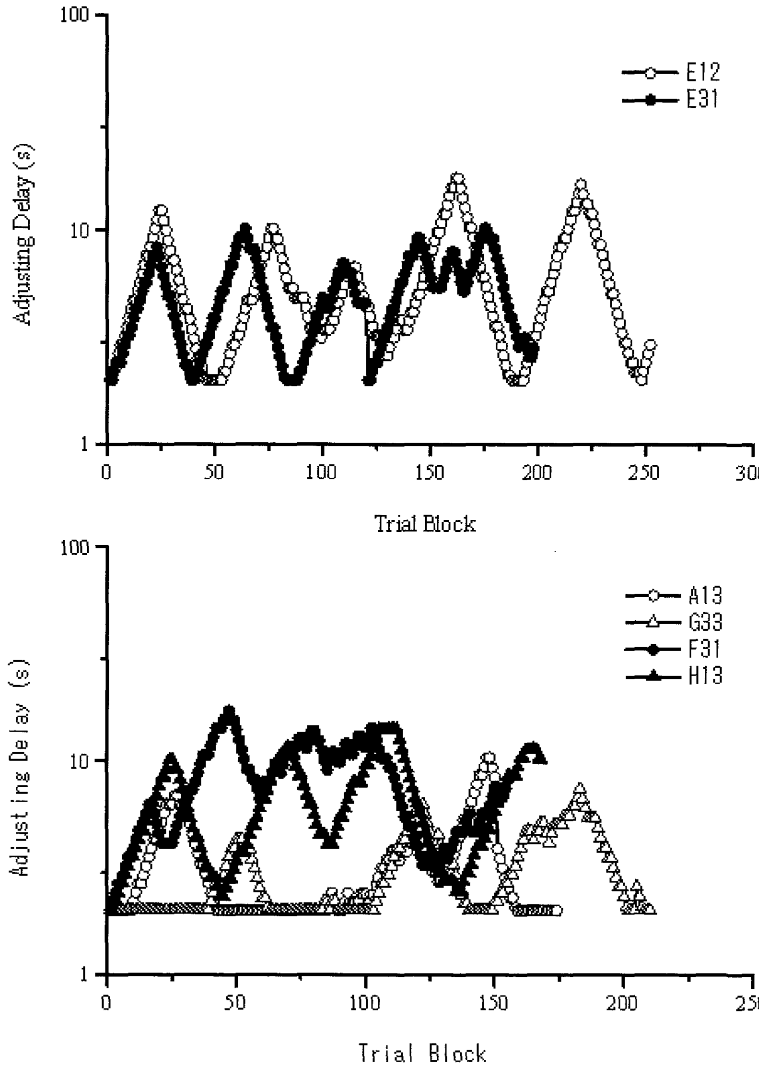

Fig. 1. Adjusting delays in successive blocks from the beginning of the experiment to the latest session. See text for details.

often stayed at 2 s. In other words, the pigeons in the choice-dependent condition tended to be more impulsive.

IV. Discussion

Although it can be misleading to state a conclusion before the adjusting delays stabilize, a tentative conclusion is that the choice-dependent condition made the pigeon more impulsive. This is the opposite of what was expected: the choice-independent condition, not the choice-dependent condition, would have made the pigeon more impulsive, because they did not have to choose later-larger reinforcers to maximize the amount of food earned in a session.

One hypothesis that can explain this result is that the pigeons were not sensitive to the total amount of food in a session but were sensitive to the total rate of food; that is, the total amount of food divided by the total time spent in a session. Because the intertrial intervals in the present procedure were adjusted so that the interval between successive trials was constant, the total rate of food was determined by the total amount food earned and the total number of trials in a session. Therefore, whereas the pigeons in the choice-dependent condition, in which the number of trials in a session was fixed, could maximize the total rate of food by maximizing the total amount of food earned in a session, the pigeons in the choice-independent condition, in which the amount of food earned in a session was fixed, could maximize the total rate of food by minimizing the number of trials in a session. Although both these strategies required the pigeons to choose later-larger reinforcers, the maximization of the total amount of food and the minimization of the number of trials were not the same in the chamber with the food hopper. The amount of food eaten from a food hopper does not increase linearly with the duration of activation of it (Epstein, 1981): When a food hopper is activated for 6 s, the amount of food eaten is less than three times of the amount of food eaten when it is activated for 2 s. On the other hand, the number of choice trials when pigeons always chose later-larger reinforcers was exactly one third of the number of choice trials when pigeons always chose sooner-smaller reinforcers. This suggests that the maximization of the total rate of food was more effective in the choice-independent condition than in the choice dependent-condition with the chamber with the food hopper. The same line of argument may explain why the adjusting delays from the two conditions drifted within the almost same range with the chamber with the pellet dispenser, which controlled the amount of food strictly (3 vs. 1 pellet).

As mentioned above, this is a tentative conclusion. To confirm it, the experiment should be continued until the adjusting delays stabilize. After that, the conditions should be reversed within individual subjects and repeated twice to counterbalance key biases by reversing the assignment of the standard and adjusting alternatives to the left and right keys.

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