



Short report

Effects of different fixed-ratio requirements on delay discounting in rats

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ARTICLE INFO

Article history:

Received 20 April 2013

Received in revised form 6 July 2013

Accepted 6 July 2013

Keywords:

Choice
 Delay discounting
 Fixed-ratio schedules
 Impulsive behavior
 Self-control
 Rat

ABSTRACT

In delay discounting, choice is between two reinforcers that differ in amount and delay, and the subjective value of either reinforcer decreases as a function of delay to its receipt. The steepness of the discounting function is thought to reflect the degree of impulsive choice. Many factors can influence impulsive choice, including the addition of a constant delay or response requirement to the smaller sooner (SS) and larger later (LL) reinforcers. A delay-discounting procedure developed by Evenden and Ryan (1996) is commonly used in behavioral research, yet effects of adding a response requirement to both alternatives with this procedure has not been examined. If different delay-discounting procedures are measuring the same phenomenon, preference reversals should occur with the Evenden and Ryan procedure as they do with other procedures with an added response requirement. The current experiment used an Evenden and Ryan procedure, and choice was examined when the response requirement was a small, intermediate, and large fixed ratio (FR). Fewer LL choices occurred with the small FR, and more LL choices occurred with the intermediate and large FR. The present experiment extends preference-reversal findings to a different and commonly used delay-discounting procedure.

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1. Introduction

Delay-discounting examines choice between reinforcers that differ in magnitude and delay (e.g., Mazur, 1987). In these contexts, self-controlled choice is defined as choice for a larger later (LL) over a smaller sooner (SS) reinforcer, and impulsive choice as the opposite. As delay to the LL reinforcer increases, choice for that alternative decreases hyperbolically (Mazur, 1987). Choice for the LL reinforcer can be increased by adding a constant delay (Ainslie and Herrnstein, 1981; Green and Estle, 2003; Green et al., 1981; Krebs and Anderson, 2012; Rachlin and Green, 1972) or response requirement to both alternatives (Boehme et al., 1986; Newman et al., 2008; Siegel and Rachlin, 1995), a phenomenon predicted by the hyperbolic discounting equation (e.g., Ainslie and Herrnstein, 1981) and referred to as a preference reversal.

Although several procedures exist, the Evenden and Ryan (1996) procedure is widely used in behavioral research (e.g., Barbelivien et al., 2008; Cardinal et al., 2000; Huskinson and Anderson, 2012; Huskinson et al., 2012; Koffarnus et al., 2011; Slezak and Anderson, 2009, 2011; Stanis et al., 2008; Winstanley et al., 2003). One advantage of this procedure is discounting functions can be obtained

more rapidly, and with similar conclusions, relative to other delay-discounting procedures (e.g., Anderson and Woolverton, 2005; Madden et al., 2008). Another advantage is that drug effects or other manipulations can be examined across several delays within a session. If different delay-discounting procedures are thought to measure the same phenomenon, it is important that they yield similar outcomes. Thus, preference reversals that are obtained in other procedures should also occur with the Evenden and Ryan procedure. The goal of the current experiment was to examine whether adding an FR to both alternatives in an Evenden and Ryan procedure would result in preference reversals that are obtained with other procedures.

2. Methods

2.1. Subjects

Six Sprague-Dawley rats (Harlan Sprague-Dawley, Inc., Indianapolis, IN) served as subjects. Four (S-1, S-4, S-5, S-6) had histories with basic schedules of reinforcement and were 12–14 months old at the start of experimentation. One (S-3) had a history with delay discounting and ethanol self-administration and was 15 months old at the start of experimentation. One (S-8) was experimentally naïve and was 3.5-months old at the start of experimentation. Rats were housed individually with access to water in their home cage. Temperature was maintained at 20°C, and

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Table 1

Subject, order of conditions, number of sessions per condition, number of 0-s probe sessions to reach 80% or greater LL choice, amount of time to complete the FR, and the mean number of switches between response alternatives per session.

Subject	Conditions	# of sessions	# of 0-s probe sessions	Time (s) to complete FR	Mean # of switches
S-1	FR 1	10	3	–/–	–/–
	FR x (45)	14	1	18.1 s	2.8
	FR 1	17	5	–/–	–/–
	FR x/2 (23)	11	1	8.0 s	2.8
	FR 1	10	–/–	–/–	–/–
S-3	FR 1	50	2	–/–	–/–
	FR x (50)	10	1	18.5	0
	FR 1	12	3	–/–	–/–
	FR x/2 (25)	14	1	7	0.4
	FR 1	12	–/–	–/–	–/–
S-4	FR 1	20	2	–/–	–/–
	FR x (20)	10	1	17.4 s	0.2
	FR 1	32	2	–/–	–/–
	FR x/2 (10)	11	1	7.4 s	0
	FR 1	16	–/–	–/–	–/–
S-5	FR 1	22	2	–/–	–/–
	FR x (40)	16	1	15.5 s	0
	FR 1	17	2	–/–	–/–
	FR x (40)	10	1	14.5 s	0.4
	FR 1	10	–/–	–/–	–/–
S-6	FR 1	18	–/–	–/–	–/–
	FR x (20)	11	1	6.9 s	0
	FR 1	41	3	–/–	–/–
	FR x/2 (10)	10	1	3.1 s	0
	FR 1	17	–/–	–/–	–/–
S-8	FR 1	43	7	–/–	–/–
	FR x (5)	12	1	4.4 s	0.4
	FR 1	56	–/–	–/–	–/–

a reverse 12-hour light–dark cycle was in place. Sessions were conducted during the dark phase at the same time each day. Subjects were fed 10–15 g of food 30 min following each session. All procedures were conducted in accordance with West Virginia University's Animal Care and Use Committee.

2.2. Apparatus

Sessions were conducted in six operant-conditioning chambers for rats. Chambers were enclosed in melamine sound-attenuating cubicles (Med Associates, St Albans, Vermont) and contained a working area of 30.5 cm by 24.5 cm by 21.0 cm, a grid floor, and a 45-mg food-pellet dispenser with a receptacle that was centered between two retractable levers. The levers were 11.5 cm apart and required a force of at least 0.25 N for a response to be recorded. Each lever was 4.8 cm wide, protruded 1.9 cm into the chamber, and was elevated 8 cm from the floor. Two 28-V stimulus lights, 2.5 cm in diameter, were 7 cm above each lever. Each contained a 28-V houselight on the wall opposite the levers. A fan circulated air and masked extraneous noise. Equipment was interfaced to a computer, and sessions and data collection were controlled with MedPC-IV software (Med Associates, VT).

2.3. Procedure

2.3.1. Delay-discounting procedure

Sessions started with a 10-min blackout, during which the chamber was dark, followed by five blocks of eight trials that started every 100 s. The first two trials in each block were forced-exposure trials with one, randomly determined, lever extended into the chamber and the cue light above it illuminated. A lever press on the extended lever resulted in the lever being retracted, the cue light darkening, and either a single food pellet was delivered immediately (SS) or three food pellets were delivered after a delay (LL).

The houselight turned on at the start of each trial, remained on during the delay to food delivery, and flashed (0.5 s) each time a pellet was delivered. After food delivery, the houselight and cue lights remained off for the remainder of the 100-s trial. At the start of the second forced-exposure trial, the other lever was extended, the cue light above it was illuminated, and the other outcome was available.

The remaining six trials in each block were free-choice trials. During these trials, the houselight and cue lights were illuminated, and both levers were extended. A press on either lever resulted in both levers being retracted, both cue lights darkening, and an SS or LL reinforcer was delivered, depending on which lever was pressed. The lever correlated with the LL reinforcer remained constant within and across sessions and was counterbalanced across subjects. If no lever press occurred within 30 s of trial onset, the trial was recorded as an omission, the lever(s) retracted, houselight and cue light(s) darkened, and no food was delivered. If six or more free-choice omissions occurred within a session, or more than three free-choice omissions occurred within a block, data from that session were not used.

In the first block, the delay to the LL reinforcer was 0 s and increased within sessions across blocks. The delays were systematically adjusted for individual subjects to a series of 0, 2, 4, 8, and 16; 0, 5, 10, 20 and 40 s; or 0, 8, 16, 32, and 64 s to obtain intermediate discounting functions that had room to shift left or right. Once determined, delay series remained in effect for the remainder of the experiment. Sessions ended after 40 trials (10 forced-exposure and 30 free-choice) and were conducted daily.

2.3.2. FR procedure

Choice was examined at small (FR 1), intermediate (FR x/2), and large (FR x) FRs where x was the largest value that maintained responding with less than six free-choice omissions or that maintained near exclusive LL choice. Choice was determined for FR 1,

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