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Short report

Human choice among five alternatives when reinforcers decay☆

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Abstract

Human participants played a computer game in which choices among five alternatives were concurrently reinforced according to dependent random-ratio schedules. "Dependent" indicates that choices to any of the wedges activated the random-number generators governing reinforcers on all five alternatives. Two conditions were compared. In the *hold* condition, once scheduled, a reinforcer – worth a constant five points – remained available until it was collected. In the *decay* condition, point values decreased with intervening responses, i.e., rapid collection was differentially reinforced. Slopes of matching functions were higher in the *decay* than *hold* condition. However inter-subject variability was high in both conditions.

Keywords: Concurrent schedules; Human subjects; Matching; Response-dependent schedules; Choice; Reinforcement magnitude

1. Introduction

The goal of this research was to enable rapid assessment of choices by human participants under concurrent schedules of reinforcement. Choices by humans often show a wide range of sensitivity to reinforcement frequencies, and many explanations have been offered (Bradshaw and Szabadi, 1988; Kollins et al., 1997). We devised a procedure that differed in a number of ways from those commonly employed and tested the influence of differentially reinforcing rapid reinforcer acquisition (explained in the next paragraph).

Participants played a computer game in which they chose among five alternatives, each alternative associated with a different random-number generator that governed reinforcement. Every response fired all five random-number generators. This schedule differed from the more common concurrent variable interval (concurrent VI-VI) in that reinforcer availability (or "set up") depended on responses, rather than passage of time, but was similar to the concurrent VI-VI procedure in that a reinforcer could set up on a given alternative whether or not the participant was responding on that alternative (for similar schedules, see Lau and Glimcher, 2005; MacDonall, 1988). In one condition, referred to as *hold*, a reinforcer remained indefinitely after set up until collected. This condition is similar to concurrent VI-VI schedules. Under another condition, referred to as *decay*, reinforcer values (the number of points potentially received) decreased with successive choices to other alternatives. The *decay* condition differentially favored immediate (or quick) access to available reinforcers. We compared *hold* and *decay* conditions in terms of stability of choices and their sensitivity to reinforcer ratios. The guiding hypothesis was that because rapid acquisition of reinforcers was differentially favored in the *decay* condition, choice distributions under decay would more closely approximate those from animal experiments where immediate access is presumably highly reinforcing.

2. Method

2.1. Participants

Twenty college-age individuals (12 males), were told that they would be paid between $8 and $15, depending on their performance and signed informed-consent forms. After the experiment, all participants were paid $15. Between one and four participants were scheduled simultaneously for 90 min experimental sessions but the experiment was performed individually at different workstations.

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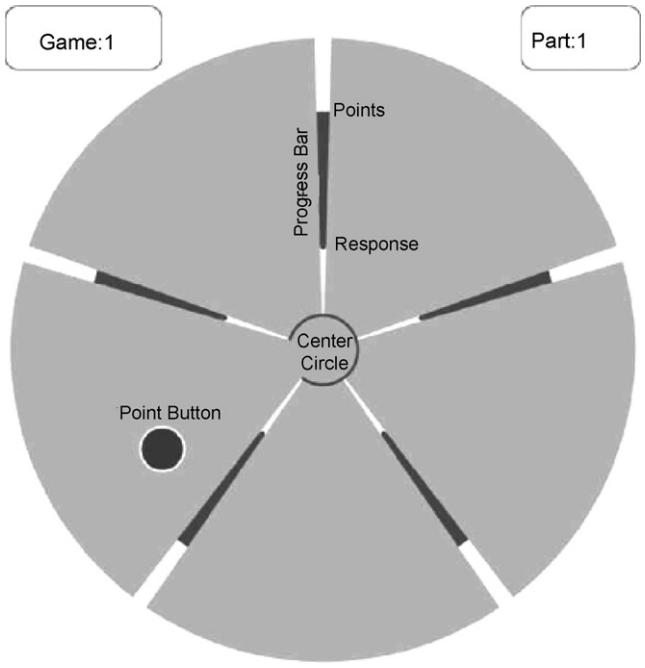

Fig. 1. Grayscale representation of computer screen.

2.2. Apparatus

A Java computer program ran on Apple iMac computers in full-screen mode (no window borders, clock, or other operating system interface elements). Participants sat at a comfortable distance from the screen and used a one-button computer mouse to interact with the program. A large circle was constantly present in the center of the screen on a black background (see Fig. 1). This circle was subdivided into five wedges with another, smaller circle in the center. Each of the wedges was a different color. Participants moved the mouse pointer (a crosshair) into the center circle. After a delay of 50 ms, the center circle changed to a lighter gray, indicating that a choice response was permitted. Any mouse movement that passed outside of the center circle before 50 ms elapsed reset that interval.

Movement of the crosshair into one of the wedges marked a response to that alternative, and the wedge flashed to indicate the choice. One of two outcomes resulted from this choice. If the response yielded a reinforcer, a small pulsating dot (approximately 0.75 in.) appeared at a randomized location within the wedge. To receive points, the participant was required to click on the pulsating dot. This led to some number of small dots moving from the location of the pulsating dot to the center circle. Each dot represented one point. As the dots completed their trajectories, they disappeared, and the number of points received was briefly displayed in the center circle (as in "+5"). If the mouse was moved into the center circle without clicking on the pulsating dot (possibly caused by hasty or inattentive responding), the dot and associated points disappeared and were lost. Most responses were not reinforced (as will be described below) and resulted only in the flash of the wedge.

To provide participants with feedback concerning their performances, progress bars moved along the spokes that separated the wedges. With each reinforcer, the front end of the bar moved toward the outer circumference of the circle, the amount of movement scaled such that the trial terminated at 250 points with the bar having reached the outer circumference. With each response, the back end of the bar moved 0.5% of the length of the spoke in the same direction. Thus, the difference between the front end (points) and back end (responses) indicated points per response, and the larger this area – referred to as the "progress bar" – the better the performance. Participants were told to "beat" the response end by gaining as many points as possible in as few responses as possible.

2.3. Procedure

The schedule of reinforcement differed from a traditional concurrent variable interval schedule in three aspects: number of response alternatives, reinforcement contingency, and, in one of the conditions, reinforcement decay. First, participants chose among five different alternatives (*A*, *B*, *C*, *D*, and *E*) rather than the more common two. Secondly, reinforcers were programmed by response-dependent random-ratio (RR) schedules with five random-number generators scheduling reinforcers, according to Bernoulli processes. Each of the five governed a different probability of reinforcer availability ($A = 0.03$, $B = 0.09$, $C = 0.18$, $D = 0.07$, and $E = 0.00$). A response to any of the alternatives activated, or "fired", all five random generators. Thus, every response could cause reinforcers to set up on none, one, or more than one of the wedges.

We compared two experimental conditions, which differed only as follows: in the *hold* condition, each obtained reinforcer was worth five points, and once a reinforcer was set up, that point value was maintained until the reinforcer was collected. Thus, the *hold* condition is similar to concurrent VI-VI schedules in which reinforcers, once set up, remain available indefinitely and the amount of reinforcement is constant. In the *decay* condition, following set up of a reinforcer, the number of points decreased exponentially upon each response to a *different* alternative. All values were integers such that the sequence of points per reinforcer was 5, 3, 2, 2, 1, 1, 0, 0, 0 . . .. Thus, if a reinforcer had set up on wedge *A* and *A* was chosen on the next response, five points were provided. However, if, following reinforcer set up, three responses were emitted to wedge *C*, then a response to *A* would produce only two points. In addition, as point values decayed, responses to the other wedges continued to activate all five random-number generators and, therefore, if the wedge *A* generator had allocated a new reinforcer prior to receipt of the two points, the value would return to its initial five point maximum. In brief, in the *decay* condition, points decayed with intervening responses, but there was some probability of the points returning to their initial values.

After participants read written instructions (see Appendix A), one of the authors (JBR) demonstrated the interface, explained the progress bar, emphasized that participant pay would be proportional to the size of the bar, and that participants should try to get as many points per response as possible. Additionally, after participants were familiar with the interface, a special "demonstration mode" was enabled that allowed participants to see the