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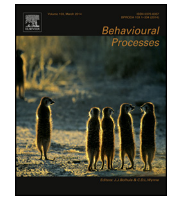

Suboptimal choice by pigeons: An analog of human gambling behavior

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ABSTRACT

Human gambling often involves the choice of a low probability but high valued outcome over a high probability (certain) low valued outcome (not gambling) that is economically more optimal. We have developed an analog of gambling in which pigeons prefer a suboptimal alternative that infrequently provides a signal for a high probability (or high magnitude) of reinforcement over an optimal alternative that always provides a signal for a lower probability (or lower magnitude) of reinforcement. We have identified two mechanisms that may be responsible for this suboptimal behavior. First, the effect of nonreinforcement results in considerably less inhibition of choice than ideally it should. Second, the frequency of the occurrence of the signal for a high probability or high magnitude of reinforcement is less important than ideally it should. Also analogous to human gambling is the finding that pigeons that are normally food restricted choose suboptimally, whereas those that are minimally food restricted choose optimally. In addition, pigeons that are singly housed choose suboptimally, whereas those that are exposed to a more enriched environment choose less suboptimally. We believe that these findings have implications for the understanding and treatment of problem gambling behavior.

1. Introduction

Problem gambling in humans is clinically recognized as an impulse control disorder in which people show impaired behavioral inhibition and a failure to consider the long-term consequences of the decisions they make (DSM-IV-TR, APA, 2000). When gambling is suboptimal, it refers to choices in which the average net return is less than what is wagered (most commercial gambling). Such gambles are typical of casino games such as slot machines, roulette, and black-jack, and are especially true of lotteries. Because the net return on such decisions is negative, the decision to choose to gamble and receive a low-probability, high-payoff outcome (losing most of the time and winning occasionally) rather than not to gamble and maintain a high-probability low-payoff outcome (the amount not wagered) is viewed as a failure to maximize gains and minimize losses.

One explanation for human gambling has to do with the fact that in most public gambling, when someone wins, it is more salient than when someone loses (bells ring and lights flash at casinos when someone wins big and big winners of lotteries are often mentioned on the news). This is sometimes referred to as an example of the availability heuristic (Tversky and Kahneman, 1974).

Interestingly, examination of the behavioral ecology literature suggests that one should not find evidence of suboptimal choice in nonhuman animals because natural selection should have selected animals to be *optimal foragers* (Stephens and Krebs, 1986). Given appropriate experience, nonhuman animals are presumed to be sensitive to the relative amounts of food obtained from different alternatives or patches (see Fantino and Abarca, 1985).

2. A rat model of human gambling

One gambling-like task that has been modified for use with animals is the Iowa Gambling Task (Rivalan et al., 2009; Zeeb et al., 2009). In the Zeeb et al. study, rats chose among four options that varied among them in the probability of reinforcement (0.4–0.9), amount of reinforcement (1–4 pellets), probability of a punishment timeout following a trial (0.1–0.6), and the duration of the timeout (5–40 s). Using this task, Zeeb et al. found that the rats chose adaptively, maximizing food pellets earned per unit time.

Interestingly, the rats failed to choose optimally when the probability of the time out was varied, even though the longer timeout meant that it occurred less often per unit time. Under those conditions, they undervalued the negative effects of the long time outs and instead were attracted to the larger magnitude of reinforcement. This meant that in so doing they received only half of the maximum number of pellets per unit time.

Rivalan et al. (2009) gave rats a choice between one alternative that provided a small amount of food on some trials and a short penalty on other trials and a second alternative that provided a

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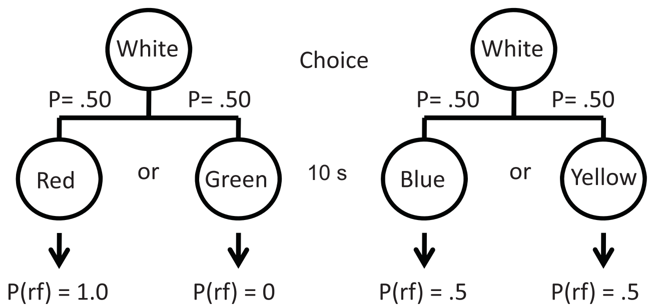

Fig. 1. Procedure used in Roper and Zentall (1999). Pigeons chose between two alternatives. Choice of one alternative (e.g., left) was followed by either a stimulus (e.g., red) 50% of the time that was always followed by reinforcement or a different stimulus (e.g., green) 50% of the time that was never followed by reinforcement. Choice of the other alternative (i.e., right) was followed by either of two stimuli (blue or yellow) both of which were followed by reinforcement 50% of the time. Spatial location and colors were counterbalanced.

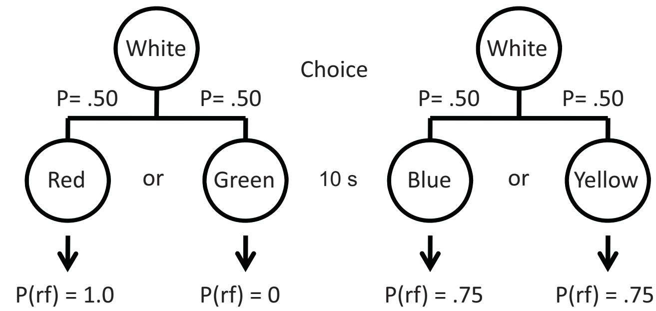

Fig. 2. Procedure used in Gipson et al. (2009). Pigeons chose between two alternatives. Choice of one alternative (e.g., left) was followed by either a stimulus (e.g., red) that was always followed by reinforcement on half of the trials or a different stimulus (e.g., green) that was never followed by reinforcement on the remaining trials. Choice of the other alternative (i.e., right) was followed by either of two stimuli (blue or yellow) both of which were followed by reinforcement 75% of the time. Spatial location and colors were counterbalanced.

larger amount of food on some trials but a very long penalty on other trials. However, because of the long penalties, the alternative associated with the larger amount of food actually resulted in only 20% as much food per unit time. Although a majority of the rats performed optimally and chose the alternative that provided a small amount of food and the short penalty, a substantial number of the rats preferred the alternative that provided a larger amount of food and the longer penalty. These results suggest that some rats may be relatively insensitive to the duration of the penalty and thus perform suboptimally in terms of the amount of food obtained per session.

3. A pigeon model of human gambling

There is substantial evidence that pigeons prefer choices that produce discriminative stimuli over those that do not. Specifically, they prefer choices that sometimes result in a strong conditioned reinforcer (followed by reinforcement 100% of the time) and sometimes result in a strong conditioned inhibitor (never followed by reinforcement) over those that result in weak conditioned reinforcers (followed by reinforcement 50% of the time) even though choice of either alternative would result in the same amount of reinforcement (see Fig. 1; Roper and Zentall, 1999).

But would pigeons prefer an alternative that produced discriminative stimuli if it resulted in a significantly lower probability of reinforcement? Apparently they would. Under the right conditions, some pigeons prefer an alternative associated with 50% reinforcement that produces discriminative stimuli (half of the time a stimulus that reliably predicted reinforcement, half of the time a different stimulus that reliably predicted the absence of reinforcement) over an alternative that *always* predicts reinforcement (Belke and Spetch, 1994; Fantino et al., 1979; Mazur, 1996; Spetch et al., 1990, 1994). Under these conditions, when given a choice between 50% reinforcement and 100% reinforcement, some pigeons choose the 50% reinforcement option (although others did not). In this case, both alternatives are associated with strong conditioned reinforcers. We will return to this condition in a later section.

In a more recent experiment, we attempted to get more consistent preferences while maintaining the lower probability of reinforcement associated with choice of the alternative followed by the discriminative stimuli (Gipson et al., 2009). In this experiment, we pitted 50% reinforcement with discriminative stimuli against 75% reinforcement with nondiscriminative stimuli (see the design in Fig. 2). These pigeons were given a choice between two white lights, one on the left the other on the right. A single peck to one light resulted in the presentation of one of two colored lights (S1 or S2) for 30 s. If it had been S1, it was always followed by reinforcement. If it had been S2, it was never followed by reinforcement. Thus, choice of that alternative resulted in the appearance of a discriminative stimulus and the overall probability of reinforcement was 0.50. A single peck to the other white light resulted in the presentation of one of two different colored lights (S3 or S4) for 30 s and in either case it was followed by reinforcement with a probability of 0.75. Thus, choice of the second alternative resulted in a higher probability of reinforcement than choice of the first alternative. To ensure that the pigeons had adequate experience with the contingencies of reinforcement associated with the two alternatives, in each training session the pigeons received 12 forced trials with each discriminative and nondiscriminative terminal link stimulus and 12 choice trials. With this design we found a statistically reliable suboptimal preference of 69% for the alternative associated with 50% reinforcement.

In a follow up study, we found that if we reduced the probability of reinforcement associated with the discriminative stimulus alternative, we could obtain an even larger preference for that alternative (Stagner and Zentall, 2010). Specifically, the probability of reinforcement associated with the discriminative stimulus alternative was only 0.20 (the stimulus that reliably predicted reinforcement occurred on only 20% of the trials), whereas the probability of reinforcement associated with the nondiscriminative stimulus alternative was 0.50 (2.5 times the probability reinforcement associated with the discriminative stimulus alternative, see Fig. 3). We also reduced the duration of the terminal link stimuli from 30 s to 10 s. Under these conditions, the pigeons showed

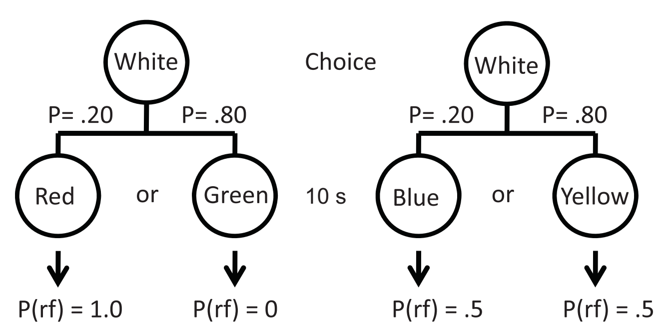

Fig. 3. Procedure used in Stagner and Zentall (2010). Pigeons chose between two alternatives. Choice of one alternative (e.g., left) was followed either by a stimulus (e.g., red) on 20% of the trials that was always followed by reinforcement or by a different stimulus (e.g., green) on 80% of the trials that was never followed by reinforcement. Choice of the other alternative (i.e., right) was followed by either of two stimuli (blue or yellow) each of which was followed by reinforcement 50% of the time. Spatial location and colors were counterbalanced.