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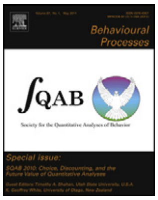

Maladaptive “gambling” by Pigeons

Thomas R. Zentall*

Department of Psychology, University of Kentucky, Lexington, KY 40506-0044, United States

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ABSTRACT

When humans buy a lottery ticket or gamble at a casino they are engaging in an activity that on average leads to a loss of money. Although animals are purported to engage in optimal foraging behavior, similar sub-optimal behavior can be found in pigeons. They show a preference for an alternative that is associated with a low probability of reinforcement (e.g., one that is followed by a red hue on 20% of the trials and then reinforcement or by a green hue on 80% of the trials and then the absence of reinforcement) over an alternative that is associated with a higher probability of reinforcement (e.g., blue or yellow each of which is followed by reinforcement 50% of the time). This effect appears to result from the strong conditioned reinforcement associated with the stimulus that is always followed by reinforcement. Surprisingly, although it is experienced four times as much, the stimulus that is never followed by reinforcement does not appear to result in significant conditioned inhibition (perhaps due to the absence of observing behavior). Similarly, human gamblers tend to overvalue wins and undervalue losses. Thus, this animal model may provide a useful analog to human gambling behavior, one that is free from the influence of human culture, language, social reinforcement, and other experiential biases that may influence human gambling behavior.

Maladaptive gambling by humans can be defined as making a decision to choose a low probability but high payoff alternative over a high probability, low payoff alternative (not gambling), such that the net expected return is less than what one has wagered. That is, choices that over the long term are very likely to result in losing more than winning. Such gambles are typical of casino games such as slot machines, roulette, and black-jack, and are especially true of lotteries. Several popular explanations have been given for what appears to be maladaptive behavior. One view is that people often are unaware of the odds of winning and if they are, they have a difficult time interpreting the meaning of those odds. For example, the value that humans give to 1:100, 1:1000, and 1:1,000,000 are relatively similar, yet the odds of their payoff are quite different. This could be considered the result of inadequate experience. A second account 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). A third possibility is that humans are social animals and there is additional social reinforcement that often accompanies winning (e.g., at casinos). Finally, people who engage in gambling behavior often describe the activity as enjoyable independent of wins and losses. Presumably, the life these people lead is not sufficiently interesting and gambling makes it more attractive.

Recently, a more analytic approach to human decision making has been suggested that may help separate more basic behavioral processes from the above mechanisms (Evans, 2003; Klaczynski, 2005). It has been proposed that human decision making depends on two different sources of input, primary and secondary processes. Primary processes are those governed by relatively simple associative learning processes, often existing without awareness (Klaczynski, 2005) and often taking the form of a “gut” level reaction, an emotion, or an impulse (e.g., Haidt, 2001; Loewenstein et al., 2001; Slovic et al., 2004). Secondary processes comprise what we normally think of as thought processes, the conscious effort to weigh options, consider possibilities, and attempt to resolve dilemmas. They consist of what humans are aware of, but they are relatively limited in capacity (Dijksterhuis, 2004; Evans, 2003) because humans are limited in the number of factors that they consciously can take into account.

According to this theory, the evaluation of risk can result from either primary or secondary decision processes. Primary processes are always in play but secondary processes can be recruited when the time to make a decision is not constrained and when decisions can be based on relatively few sources of information (Dijksterhuis, 2004; Greene et al., 2008). Also it is often the case that secondary processes are retrospective and come into play after the decision is made. That is, after decisions are made using primary processes,

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* Tel.: +1 859 257 4076; fax: +1 859 323 1979.
E-mail address: zentall@uky.edu

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individuals may consider the reasons for having made those decisions (sometimes referred to as rationalization, Smith and Mackie, 2007). This leads to a curious phenomenon. One may believe that a decision was made rationally (based on secondary processes) for the purpose of justifying how it was made, when in fact it was made largely under the control of primary processes. Thus, it may be that many of the processes that govern human decision making are of the primary type. If this analysis is correct, one may be able to study such decision making processes more directly in animals because their decisions are also likely to be largely under the control of primary decision processes.

However, examination of the behavioral ecology literature suggests that one should not find evidence of maladaptive gambling in nonhuman animals (choice of an alternative that provides less reward) as long as they are given adequate experience with the alternatives. According to optimal foraging theory, animals should be less susceptible to the attraction of a poor gamble because their survival is likely to be at stake (Stephens and Krebs, 1986). That is, animals should make optimal choices because evolution should have favored the survival of animals that do (MacArthur and Pianka, 1966). 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).

1. Animal models of human gambling

Thus, it is reasonable to ask if nonhuman animals show choice behavior analogous to the sub-optimal behavior shown by humans when humans purchase a lottery ticket or engage in casino gambling. One task that has been modified for use with animals (rats) 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 continued to choose optimally when the duration of the timeout was equated over conditions (the duration of the timeout appeared to have little effect on the rats choice) but they failed to choose optimally when the probability of the time out was equated (the probability of the timeout and thus the probability of reinforcement enhanced the value of the large reinforcer 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, and by so doing they received only half of the maximum number of pellets per unit time.

Rivalan et al. (2009) also gave rats a choice between an alternative that provided a small amount of food on some trials and a short penalty on other trials and an alternative that provided a larger amount of food 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 sub-optimally in terms of food per unit time.

Research that we have conducted with pigeons using a simpler task that may be more analogous to human gambling suggests that they, like humans, may be susceptible to maladaptive choices. The origins of this research go back to a line of research that assessed the degree to which animals would work for information, independently of differential reinforcement. That is, research that was conducted to ask if animals would choose to obtain a signal for reinforcement or a signal for its absence even when those signals had no effect on the probability of reinforcement associated with those choices.

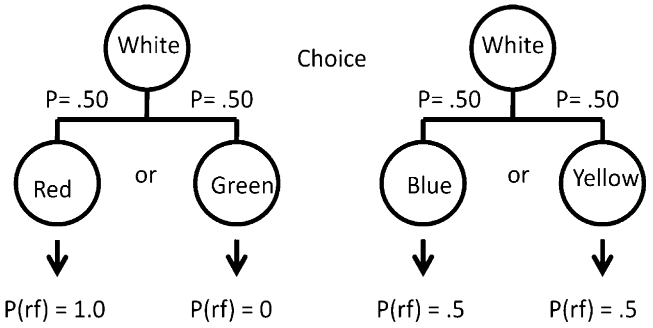

Fig. 1. Design of experiment by Roper and Zentall (1999). Pigeons chose between two alternatives. Choice of one alternative was followed by either a stimulus (red) that was always followed by reinforcement or a different stimulus (green) that was never followed by reinforcement. Choice of the other alternative 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.

2. Information or conditioned reinforcement?

We (and others) have shown, in fact, that when the probability of reinforcement is equated, pigeons prefer to obtain stimuli that signal reinforcement or its absence over stimuli that ambiguously signal reinforcement (Dinsmoor, 1983; Roper and Zentall, 1999). In Roper and Zentall's procedure, on half of the trials, choice of one alternative resulted in the presentation of a stimulus that reliably predicted reinforcement and on the other half of the trials resulted in the presentation of a stimulus that reliably predicted the absence of reinforcement. Technically, these stimuli should be referred to as a conditioned excitatory and conditioned inhibitory stimulus, respectively, if responding is not required to the signal for reinforcement, but in the present article I will refer to them as discriminative stimuli because pigeons generally peck at stimuli that predict reinforcement whether they are required to or not and they refrain from pecking at stimuli that predict the absence of reinforcement. Thus, choice of the first alternative was associated with 50% reinforcement (see the left side of Fig. 1). Choice of the other alternative resulted in the presentation of one of two stimuli each of which was followed by reinforcement 50% of the time (see the right side of Fig. 1).

Roper and Zentall (1999) found that the pigeons showed a strong preference for the first alternative, the one that was followed by presentation of discriminative stimuli. This result has sometimes been taken as evidence that animals prefer information over its absence. According to information theory (Shannon and Weaver, 1949) maximal information (uncertainty reduction) should occur when there is the largest discrepancy between the information available prior to the choice and the information provided following the choice. Specifically, prior to the choice, the delivery of reinforcement was most uncertain (50%). Thus, the appearance of the discriminative stimulus provided the greatest reduction in uncertainty (either 100% or 0% reinforcement).

To test this theory, Roper and Zentall manipulated the overall probability of reinforcement (while holding equal the probability of reinforcement associated with both alternatives). Consistent with information theory, when the overall probability of reinforcement associated with both alternatives was high, 87.5%, although there was still a preference for the alternative that that was followed