Decision making by humans in a behavioral task: Do humans, like pigeons, show suboptimal choice?

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Abstract Consistent with human gambling behavior but contrary to optimal foraging theory, pigeons show a strong preference for an alternative with low probability and high payoff (a gambling-like alternative) over an alternative with a greater net payoff (Zentall & Stagner, *Proceedings of the Royal Society B*, 278, 1203–1208, 2011). In the present research, we asked whether humans would show suboptimal choice on a task involving choices with probabilities similar to those for pigeons. In [Experiment 1](#), when we selected participants on the basis of their self-reported gambling activities, we found a significantly greater choice of the alternative involving low probability and high payoff (gambling-like alternative) than for a group that reported an absence of gambling activity. In [Experiment 2](#), we found that when the inhibiting abilities of typical humans were impaired by a self-regulatory depletion manipulation, they were more likely to choose the gambling-like alternative. Taken together, the results suggest that this task is suitable for the comparative study of suboptimal decision-making behavior and the mechanisms that underlie it.

Keywords decision making · suboptimal choice · gambling · humans · pigeons

A subset of suboptimal decision making can be characterized as making a decision to choose a low-probability but

high-payoff alternative (e.g., playing slot machines or buying lottery tickets) over a high-probability, low-payoff alternative (not gambling), such that the net expected return is less than what one has wagered. In this kind of gambling, over the long term, one is very likely to lose more than one wins, and having sufficient experience with the game to learn about the odds of winning does not appear to reduce its frequency. It appears that gamblers tend to over-attend to wins and discount losses (the availability heuristic; Tversky & Kahneman, 1974).

Recently, Zentall and colleagues studied suboptimal decision-making processes in pigeons (Gipson, Alessandri, Miller, & Zentall, 2009; Stagner & Zentall, 2010; Zentall & Stagner, 2011). They asked whether pigeons would show choice behavior analogous to the suboptimal behavior shown by humans when humans purchase a lottery ticket or engage in casino gambling. To answer this question, Zentall and Stagner designed a task that may be considered analogous to human gambling (see Fig. 1a). In this task, pigeons are given a choice between one alternative reliably associated with three reinforcers (analogous to money in one's pocket) and a second alternative (analogous to gambling) associated with a low-probability, high-payoff stimulus on some trials (10 pellets on 20% of the trials) or a high-probability, zero-payoff stimulus on others. In one sense, the task is analogous to suboptimal human gambling, because the average payoff for the first alternative (with an overall mean reinforcement per trial of 3 pellets) is greater than that of the second alternative (with an overall mean reinforcement per trial of 2 pellets). Results showed that pigeons prefer the low-probability–high-payoff (gambling-like alternative) over the greater net payoff of the high-probability–low-payoff. Although it might be argued that under conditions of a negative energy budget (e.g., the 3-pellet option would not be sufficient to keep the pigeon alive), animals will choose the risky (variable) option (Stephens, 1981), the

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Fig. 1 **a** Design of the pigeon “gambling” task (after Zentall & Stagner, 2011). Pigeons chose between two alternatives. Choice of one alternative, for example, was followed by either a red stimulus on 20% of the trials that were always followed by 10 pellets of reinforcement or a green stimulus on 80% of the trials that were never followed by reinforcement. Choice of the other alternative was followed, for example, by either a blue or a yellow stimulus, both of which always were followed by 3 pellets of reinforcement. Spatial location and colors were counterbalanced. **b** Design of the human analogue of the pigeon “gambling” task: Examples of screen captures

from the video game. Participants chose between two alternatives (two planetary systems: ZORB or ARTO). Choice of one alternative (ZORB) sent the participant to shoot at enemy spaceships on a red planet on 20% of the trials that were followed by the killing of 10 enemy generals or a green planet on 80% of the trials that were followed by the killing of no enemy generals. Choice of the other alternative (ARTO) sent the participant to shoot at enemy spaceships either on a blue planet on 20% of the trials or on a yellow planet on 80% of the trials, both of which were always followed by the killing of 3 enemy generals. Planetary systems and colors were counterbalanced

pigeons in the cited studies were not in such a state. Thus, these results are consistent with human gambling behavior but contrary to optimal foraging theory (MacArthur & Pianka, 1966).

The recent demonstration that pigeons show suboptimal gambling-like behavior under conditions that may be similar to those under which humans gamble suggests that gambling may involve basic behavioral processes that can be studied with the pigeon task. Human performance on a similar task would be valuable, because it has been argued that the mechanisms responsible for human gambling behavior are difficult to identify, findings are difficult to interpret, and conclusions are sometimes quite speculative because of the lack of a valid comparative model of suboptimal decision making (Raylu & Oei, 2002; Van Host, Van den Brink, Veltman, & Goudriaan, 2010).

In Experiments 1 and 2 of the present study, using an analog version of the pigeon task, we tested participants who were given a choice between one alternative associated

with a greater net payoff and a second alternative involving a low-probability–high-payoff (gambling-like alternative). In Experiment 1, we compared participants with a self-reported gambling habit with participants who did not gamble. In Experiment 2, we asked whether we could affect the tendency of participants to choose suboptimally by using a self-regulatory depletion manipulation that has been shown to increase risk-taking behavior (Bruyneel, DeWitte, Franses, & Dekimpe, 2009).

Experiment 1

Zentall (2011) proposed that procedures developed with pigeons resulted in choice behavior that is analogous to suboptimal human gambling behavior. If the pigeon task used by Zentall and Stagner (2011) is an appropriate animal analog of human gambling, it would be expected that humans who gamble would show suboptimal choice behavior under

conditions that mimic the pigeon's choice behavior with this task. A good test of the pigeon task as an analog of human gambling would be to compare the choice behavior of participants who are self-reported gamblers with that of those who say that they do not gamble. To examine the performance of humans on a task conceptually similar to that in Zentall and Stagner, an analog task in the form of a video game was developed. Exploration of similarities and differences between human and nonhuman learning processes can be simplified by the use of video games with humans (e.g., Herbranson, Fremouw, & Shrimp, 1999, 2002; Herbranson & Shroeder, 2010; Madden, Ewan, & Lagorio, 2007; Rayburn-Reeves, Molet, & Zentall, 2011; Rosati & Stevens, 2009).

In our computer task, participants chose between two alternatives (two planetary systems: ZORB or ARTO). Choice of one alternative (ZORB) sent the participant, on 20% of the trials, to shoot at enemy spaceships on a red planet that was followed by the killing of 10 enemy generals (variable magnitude of 10 ± 1 reinforcers) or, on 80% of the trials, a green planet that was followed by the killing of no enemy generals (the gambling-like alternative). Choice of the other alternative (ARTO) sent the participant to shoot at enemy spaceships on either a blue planet on 20% of the trials or a yellow planet on 80% of the trials, both of which were always followed by the killing of 3 enemy generals (variable magnitude of 3 ± 1 reinforcers).

Method

Participants and survey

Twenty undergraduate students (age, 18–23 years; 50% of each sex) from the University of Kentucky were selected to participate in this study on the basis of their responses to a survey consisting of eight items about gambling activities given to 877 students who were taking an introductory psychology course at the University of Kentucky. They were assigned to two groups: *non-gambling habit* and *gambling habit* (both $n_s = 10$).

Participants were asked to indicate how often they engaged in gambling activities—specifically, (1) national or other lotteries; (2) bingo, scratch cards, or other "paper" games; (3) football pools, bets on sports, and so forth; (4) slot machines or other gambling machines; (5) casino table games; (6) Internet gambling; (7) betting on horses, dogs, or other animals; and (8) playing a card game or game of skill for money. For each item, answers were given on a scale ranging from *never* (1) to *monthly* (2) to *weekly* (3), to *daily* (4). A score of 1 on all questions was used to identify participants who did not gamble, and participants who answered 3 or 4 on any one question were identified as participants who gambled. Of the students who responded to the questionnaire, 41 were identified as gamblers (or fewer than 5%, approximately 50% male

and 50% female). Among all the students who were identified as nongamblers, we randomly selected 41 students. All the selected participants were contacted by e-mail to participate in a decision-making study. The first 5 male and 5 female students from each of the gambling and nongambling groups who signed up were used in the study. Thus, 10 participants from each group served in the study.

Apparatus

Participants performed the experiment in isolated cubicles using a Dell Latitude E540 (with a standard mouse) with a monitor resolution of $1,024 \times 768$ pixels and a 32-bit color set. The video game was developed by using Visual Basic 6.0 (Microsoft).

In this task, the computer monitor displayed a rectangular viewing screen (10 cm high $\times$ 9 cm wide) on a black background. A box (0.5 cm high $\times$ 4.5 cm wide) was displayed at the top of the viewing screen, where the words "Planetary System" in phase 1 or "Choose a Planetary System" in phase 2 appeared in black on a soft gray background. A trial started when the participant clicked on the play button centered on the top of the box. Radio buttons (1 cm high $\times$ 1 cm wide), where the word "ARTO" on one or "ZORB" on the other (in black on a soft gray background) could appear on either side of the box, served as the initial link. A click on the play button presented the word "ARTO" or "ZORB" on each trial in phase 1, whereas in phase 2 a click on the play button presented both words simultaneously. A click on either "ARTO" or "ZORB" changed the background of the computer screen to one of four different background colors (i.e., soft red, blue, green, or yellow) and displayed one of the four different colored alien landscapes on the viewing screen (i.e., mountains, desert, volcanoes, or meteor craters), which served as terminal links. Enemy spaceships (1 cm high $\times$ 1 cm wide) were represented as a soft red, blue, green, or yellow spaceship (matching the color of the background of the computer screen). The spaceships appeared in 1 of 12 possible positions, for 500 ms each in a random sequence, on the viewing screen, unless it was destroyed by the participant. The participant could destroy the spaceship by clicking on it with the left button of the mouse when the cursor was on the spaceship. Destruction of the enemy spaceship was represented by a red explosion (1.7 cm high $\times$ 1.7 cm wide). A new enemy spaceship was immediately presented in some other position. After shooting down at least five spaceships in an interval of 10 s, the colored background turned black, the alien landscape and the spaceships disappeared, and a message appeared for 2 s indicating the number of generals killed (e.g., 10, 3, or 0). Aside from the minimum number of spaceships destroyed, the number of generals killed was unrelated to the number of spaceships destroyed but was

determined by the planet visited (i.e., the color and appearance of the alien landscape). The message “Generals Killed $\square$ ” was centered on the viewing screen, and an image of a purple alien (1 cm high $\times$ 0.7 cm wide) was presented to the left of the message. The number of generals killed served as the reinforcer.

Procedure

Participants gave informed consent, and the procedure had institutional ethics approval. **Experiment 1** was conducted in two phases (20 forced trials and 20 choice trials, respectively). At the start of the experiment, each participant was placed in front of the computer screen. Instructions were presented in a white rectangular window on the screen.

In phase 1, the following instructions appeared on the computer screen:

You are about to play a space-war video game. Two planetary systems are being assaulted: ARTO and ZORB. On top of the screen are two displays that will indicate in which planetary system you are fighting. Each planetary system has two different planets. When you are in ARTO, you could go to two different planets (represented by two colors) and when you are in ZORB, you could go to two other planets (represented by two different colors). It is your job to destroy the enemy spaceships by using your laser-gun (the mouse). To shoot, click the left button of the mouse while the pointer is on the target. Some spaceships will have no generals on board, some will have one or more generals on board. We don't know which spaceships have generals in them, so try to shoot as many spaceships as you can. When each battle is over, you will be informed about the number of generals that you killed. When the experiment is over a message will inform you that you can leave the room. If the instructions on the screen are unclear, please re-read them now. Otherwise, click below to start.

Phase 1: 20 forced trials On forced trials, either the word “ARTO” or “ZORB” was presented on one of the two side buttons. Each button was randomly presented 10 times. If ZORB appeared on a button, 20% of the time the background color would be, for example, red, and the alien landscape would be an image of mountains. In this case, after shooting down at least five enemies in a period of 10 s, a message indicated that 9 or 10 or 11 generals were killed (i.e., variable magnitude of 10 generals killed). The other 80% of the time, the background color would be, for example, green, and the alien landscape would be an image of a desert. In this case, after shooting down at least five enemies in a period of 10 s, a message indicated that no general was killed. If ARTO had been presented, 20% of the time the

background color would be, for example, blue, and the alien landscape would be an image of volcanoes. The other 80% of the time, the background color would be, for example, yellow, and the alien landscape would be an image of meteor craters. In both cases, if five enemies were shot down in 10 s, a message indicated that 2 or 3 or 4 generals had been killed (i.e., variable magnitude of 3 generals killed). Planetary systems and colors were counterbalanced over participants.

After completion of phase 1, the participants received the following instructions:

Good! Now you will get to choose in which planetary system you will engage in a fight. To choose a destination you will have to click on the designated button with the name of the planetary system (on top of the screen). As before, some spaceships have no generals on board and some have one or more generals on board. We don't know in which spaceships have generals in them, so try to shoot as many as you can. When each battle is over, you will be informed about the number of generals that you have killed. When you are ready click below to start.

Phase 2: 20 choice trials The procedure for choice trials was identical to the one used for forced trials, except for the following. On each choice trial, participants chose between the two planetary systems ZORB or ARTO, which were simultaneously presented in the left and right radio buttons. The unchosen planetary system was darkened.

After completing the experiment, the participants received the following instructions:

Thank you for participating in this study. You can leave this room and look for the experimenter.

A schematic of the design is presented in Fig. 1b, and an animated version can be viewed at <http://www.uky.edu/~zentall/gambling/video/>.

Results and discussion

Our dependent measure was the percentage of choices of the alternative involving low probability and high payoff (gambling-like alternative). Although any choice of the suboptimal alternative would be considered a deviation from optimality, we considered the choices of self-reported nongamblers to be a baseline against which to assess the choices of self-reported gamblers. Thus, whatever the choice of the suboptimal alternative, we asked whether participants who were self-reported gamblers would choose suboptimally more often than participants who were self-reported nongamblers.

The mean percentages of choice of the gambling-like alternative (the low-probability–high-reinforcement alternative) by

self-described gamblers and nongamblers are presented in Fig. 2. As can be seen in the figure, choice of the gambling-like alternative by the gambling group ($M = 56.5\%$, 95% CI [40, 73.1]) was higher than choice of the gambling-like alternative by the nongambling group ($M = 23.0\%$, 95% CI [9.8, 36.9]). The difference in choice of the gambling-like alternative between the two groups was statistically reliable, $t(18) = 3.57$, $p = .002$, Cohen's $d = 1.60$.

Self-reported gamblers showed a higher tendency to make suboptimal decisions, as compared with nongamblers, in a modified version of the pigeon task. In comparing the present results with those of the pigeons, we can conclude that gamblers, like pigeons, showed a tendency to make an increased number of suboptimal choices on this gambling-like task. Recently, the Iowa gambling task for humans has been modified for use with rats (Rivalan, Ahmed, & Dellu-Hagedron, 2009). Interestingly, the rats showed a profile in choice behavior that resembled that of humans. We believe that such models are crucial to understanding in more detail the underlying behavioral processes of decision making.

Although this is highly suggestive of a qualitative similarity in the way pigeons (Zentall & Stagner, 2011) and gamblers perform the gambling task, there is a quantitative difference. Although pigeons showed a strong preference for the suboptimal alternative over the optimal alternative (pigeons generally chose suboptimally at greater than 85%; see Zentall & Stagner, 2011), gamblers did not. However, with this task, one must view any choice of the alternative

associated with the infrequent high-valued outcome as less than optimal. Thus, it is noteworthy that choices made by gamblers and pigeons were both suboptimal but the effect was larger in pigeons.

Experiment 2

Given that this task can serve as a measure of the tendency to choose suboptimally, it may be of value to examine variables that may contribute to or detract from gambling-like behavior. One variable that has been shown to affect gambling and risk taking is self-regulatory (i.e., executive control) strength (Bruyneel et al., 2009; Freeman & Muraven, 2010). Extensive research with human and nonhuman animals suggests that the ability to self-regulate (i.e., control attention, behavior, and emotions) is limited by its reliance on a finite resource that can be depleted (for reviews, see Baumeister & Heatherton, 2004; Baumeister & Tierney, 2011; Miller, Pattison, DeWall, Rayburn-Reeves, & Zentall, 2010). Initial acts that require self-regulation deplete this common resource, and once it is depleted, subsequent efforts to control behavior generally become impaired (Baumeister, Bratslavsky, Muraven, & Tice, 1998). For example, Bruyneel et al. showed that initial self-regulation subsequently increased lottery gambling, relative to control conditions. Convergent evidence was reported by Freeman and Muraven, who found that following initial self-regulation, depleted participants reported greater inclinations for risk taking and took more risks on a task that correlated highly with gambling (i.e., the balloon analogue risk task; Lejuez et al., 2002). This increase was not correlated with changes in mood, arousal, or frustration between conditions. Furthermore, depletion was associated with risk taking to a greater degree than trait self-control. In other words, a situational variable independently influenced gambling behavior and did so more than a personality variable measured by self-reports.

The purpose of Experiment 2 was to examine whether self-regulatory depletion would also increase suboptimal choice on the pigeon analog gambling task. We adopted the two-task paradigm that is commonly used in social psychology and asked participants to initially complete a task known to reliably deplete self-regulatory strength (DeWall, Baumeister, Gailliot, & Maner, 2008; DeWall, Baumeister, Gailliot, & Stillman, 2007; Schmeichel, Vohs, & Baumeister, 2003). This attention control task required participants either to control their attention while watching a video by inhibiting reading words displayed at the bottom of the screen (*depleted* condition) or to watch the video normally (*nondepleted* condition). This task was selected because previous research had shown that participants adhere to the instructions and consistently report that controlling attention is more difficult than watching normally. Following completion of the initial task, the participants completed the adapted version of the pigeon choice

Fig. 2 The results of Experiment 1. Mean percentages of choice of the low probability of high reinforcement alternative in the nongambling habit group (participants who scored low on the gambling questionnaire) and the gambling habit group (participants who scored high on the gambling questionnaire). The “—” represents the group means, error bars indicate the standard error of the mean (SEM), and “◇” represents the data from individual participants

task. We hypothesized that participants would be more likely to choose the gambling-like alternative (low probability of high reward) in our video game version of the task when depleted, in comparison with when nondepleted, because they would be less able to inhibit impulsive responding.

Once again, because any choice of the suboptimal alternative would be considered a deviation from optimality, in Experiment 2 we considered the choices of participants in the nondepleted condition to be a baseline against which to assess the choices of participants in the depleted condition.

Method

Participants

Thirty undergraduate students (age, 18–23 years; approximately 50% of each sex) from the University of Kentucky were recruited to participate in this study on the basis of the uniformly low gambling scores they gave to the survey questionnaire we used in Experiment 1. They were randomly assigned to two groups: nondepleted and depleted (both $n_s = 15$).

Apparatus and procedure

The apparatus and procedure of Experiment 2 were the same as those of Experiment 1, except that before the video game was administered, participants were required to watch a 7-min videotape (without audio) on the computer (Dell Latitude E540) that depicted a woman being interviewed by an interviewer located off-camera. In addition to the woman being interviewed, a series of common one-syllable words (e.g., *tree*) appeared at the bottom of the screen, each for 10 s. The words appeared in black font and were presented on a white background.

The experimenter instructed participants assigned to the depletion condition “not to read or look at any words that may appear on the screen.” The experimenter reiterated the importance of not looking at the words presented at the bottom of the screen by instructing participants to redirect their gaze immediately if they caught themselves looking at the words, instead of at the woman. In contrast, the experimenter instructed the participants in the nondepleted condition to watch the video clip as they would a program presented on the television. Both the video and the instructions were identical to those used in previous self-regulatory research (DeWall et al., 2008; DeWall et al., 2007; Schmeichel, et al., 2003). After participants had finished watching the video clip, they completed the video game we used in Experiment 1.

Results and discussion

Participants who were instructed to refrain from reading the words (i.e., depleted condition) showed a greater tendency

to choose the gambling-like alternative that led to the low probability of high reinforcement than did the participants who were not instructed to refrain from reading the words (i.e., nondepleted condition). The mean percentages of choice of the gambling-like alternative for the nondepleted and the depleted groups appear in Fig. 3. As can be seen, choice of the alternative associated with a low probability of high reinforcement in the depleted group ($M = 55\%$, 95% CIs [41, 70.2]) was higher than the choice of the same alternative in the nondepleted group ($M = 38\%$, 95% CIs [26.8, 49.2]). The difference in choices between the two groups was reliable, $t(28) = 2.05$, $p = .049$, Cohen's $d = 0.75$.

The data suggest that depleted participants were more risk prone than nondepleted participants. This observation is in line with the published literature on self-regulatory depletion and risk taking (Bruyneel et al., 2009; Freeman & Muraven, 2010) and with research finding that self-regulatory exertion reduces behavioral control across numerous domains (i.e., attention, behavioral inhibition, emotion; Baumeister & Heatherton, 2004).

From a comparative perspective, our results suggest a qualitative similarity in the way pigeons and people who are depleted perform the gambling task (Zentall & Stagner, 2011). However, a quantitative difference exists in the way pigeons and people who are depleted perform the gambling task, because pigeons showed a strong preference for the suboptimal alternative, whereas people who were depleted

Fig. 3 The results of Experiment 2. Mean percentages of choice of the low probability of high reinforcement alternative in the depleted (participants who were instructed to ignore words while watching the video) and the nondepleted groups (participants who watched the video normally). The “—” represents the group means, error bars indicate SEM, and “◇” represents the data from individual participants

showed only a moderate choice of the alternative with the lower net outcome. This is similar to what we found in [Experiment 1](#).

General discussion

The results of the present experiments indicate that the pigeon gambling task (Zentall & Stagner, 2011) may be a reasonable analog of human gambling behavior. In [Experiment 1](#), we found that humans who gamble, more so than humans who do not, show a tendency to make suboptimal decisions with this task. And in [Experiment 2](#), we found that depleted non-gambling participants were more likely to choose the alternative associated with a low-probability-high-payoff than were nondepleted participants (see Bruyneel et al., 2009; Freeman & Muraven, 2010).

Although pigeons generally showed greater suboptimal choice than did the humans tested in these experiments (pigeons generally chose suboptimally at greater than 85%; see Stagner & Zentall, 2010; Zentall & Stagner, 2011), direct comparison of the present findings from humans with previous research with pigeons is made difficult by differences in procedure and past experience. For example, to occupy the humans during the relatively long interval between choice and outcome and to make the association between choice and outcome less explicit, we had the humans play a video game with the planets serving as the discriminative stimuli, rather than simple colors for pigeons. Also, the pigeons had extensive experience with the contingencies associated with the initial and terminal stimuli (over 2,000 trials), whereas participants in the present experiments had much less training (20 forced trials followed by 20 choice trials). The ecological validity of human analog to decision making could perhaps be improved by extending the training session (see Madden et al., 2007). Potentially, a more important factor is likely to be the difference in level of motivation between the pigeons and the humans. Our participants may have been minimally motivated by credit toward their research participation requirement, whereas the pigeons in our experiments received the majority of their daily allotment of food during the experiment. It is very likely that the level of motivation of the pigeons was quite a bit higher than that of the humans, and perhaps we could have increased the level of motivation of the humans by rewarding them with money rather than points. There is some evidence that the real or symbolic nature of the rewards can affect decision making (e.g., Lagorio & Madden, 2005). In fact, we recently found that when pigeons performed the pigeon version of this task under lower conditions of motivation (less food deprived), they showed less of a tendency to make suboptimal choices than did more highly motivated pigeons (Laude, Pattison, & Zentall, 2011) with a result similar to that shown by our self-reported gamblers and depleted participants.

Another variable that appears to affect pigeons' performance on this task is exposure to an enriched environment. Recent work in our lab showed that pigeons that spent 4 h a day in a large group cage (enriched) showed less of a tendency to choose suboptimally than nonenriched pigeons. Clearly, our human university students were more like enriched pigeons than our normally singly-housed pigeons. Although it is not appropriate to make direct comparisons between the choice behavior of pigeons and humans, for all of the reasons already mentioned, it appears that this task can distinguish between self-described gamblers and non-gamblers ([Experiment 1](#)) and that, when the inhibiting abilities of typical humans are impaired by a self-regulatory depletion manipulation, they are more likely to choose the gambling-like alternative ([Experiment 2](#)). The results of the present experiments represent only a first approximation of a comparative model of suboptimal decision making. It is likely that our participants were not characterized by continued and uncontrollable gambling in the face of financial losses, as one might expect of pathological gamblers and people who score high on the South Oaks Gambling Screen (Lesieur & Blume, 1987). It is very likely that if our task were used on pathological gamblers, greater degrees of suboptimal choice would be found.

It is interesting to speculate about the mechanism responsible for this suboptimal behavior. Breen and Zuckerman (1999) have reported that humans who gamble regularly have been found to attend more to their wins and less to their more frequent losses. If so, it would suggest that the actual choice that participants are making is between the value of 10 generals (or pellets) that can be obtained when choosing one alternative and the value of 3 generals (or pellets) that can be obtained when choosing the other alternative. In effect, for gamblers and for depleted participants, the 0-general outcome appears to be largely ignored.

The mechanism responsible for this suboptimal behavior may be the contrast between the expectation of reinforcement associated with the alternative prior to its selection and the expectation of reinforcement associated with the stimulus that appears after the alternative has been chosen (Zentall, Clement, Friedrich, & DiGian, 2006). For the variable reinforcer alternative (i.e., an average of two pellets or two generals), when the stimulus (i.e., the colored key or planet) that is associated with 10 reinforcers appears, there is a large amount of positive contrast (an increase from 2 expected on average to 10 obtained). However, when the stimulus that is associated with 0 reinforcers appears, the resulting negative contrast is relatively small (a decrease from 2 expected to 0 obtained). For the 3-reinforcer alternative, there should be no contrast because, on every trial, 3 reinforcers are expected and 3 reinforcers are obtained. Thus, because of the positive contrast experienced with the risk-taking option, humans who gamble, depleted participants, and pigeons tend to overvalue their wins

and undervalue their more frequent losses. As far as we know, our preparation is one of the few that has addressed the hypothetical role of the relative absence of conditioned inhibition in the preference for the alternative associated with the lower probability of reinforcement. Interestingly, a theory based on the absence of conditioned inhibition to losses has been proposed to account for human gambling behavior (Breen & Zuckerman, 1999).

Taken together, the results suggest that gambling behavior may involve a basic behavioral process that can be studied comparatively with this task. Research with this procedure may help determine why it is that humans (gamblers and others under some conditions) and pigeons do not appear to make more optimal choices.

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