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Do Pigeons Prefer Alternatives That Include Near-Hit Outcomes?

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Pigeons show suboptimal choice on a gambling-like task similar to that shown by humans. Humans also show a preference for gambles in which there are near hits (losses that come close to winning). In the present research, we asked if pigeons would show a preference for alternatives with near-hit-like trials. In Experiment 1, we included an alternative that presented a near hit, in which a stimulus associated with reinforcement (a presumed conditioned reinforcer) changed to a stimulus associated with the absence of reinforcement (a presumed conditioned inhibitor). The pigeons tended to avoid this alternative. In Experiment 2, we varied the duration of the presumed conditioned reinforcer (2 vs. 8 s) that changed to a presumed conditioned inhibitor (8 vs. 2 s) and found that the longer the conditioned reinforcer was presented, the more the pigeons avoided it. In Experiment 3, the near-hit alternative involved an ambiguous stimulus for 8 s that changed to a presumed conditioned reinforcer (or a presumed conditioned inhibitor) for 2 s, but the pigeons still avoided it. In Experiment 4, we controlled for the duration of the conditioned reinforcer by presenting it first for 2 s followed by the ambiguous stimulus for 8 s. Once again, the pigeons avoided the alternative with the near-hit trials. In all 4 experiments, the pigeons tended to avoid alternatives that provided near-hit-like trials. We concluded that humans may be attracted to near-hit trials because near-hit trials give them the illusion of control, whereas this does not appear to be a factor for pigeons.

Keywords: suboptimal choice, gambling, near-hit events, pigeons

Commercial gambling generally involves suboptimal choice, because the returns are usually less than the investment, yet persistent or pathological gambling is observed in roughly 3% of the human population (American Psychiatric Association, 1994). One characterization of gambling is choice of an alternative that has a low probability of a high payoff or jackpot. The fact that evidence for similar suboptimal choice, using several different procedures, can be found in animals (Laude, Stagner, & Zentall, 2014; Stagner, Laude, & Zentall, 2012; Stagner & Zentall, 2010; Zentall & Stagner, 2011a, 2011b) suggests that a basic behavioral mechanism may be involved. For example, Stagner and Zentall gave pigeons a choice between (a) an alternative that 20% of the time produced a stimulus that was followed by reinforcement (but 80% of the time produced a stimulus that was followed by the absence of reinforcement) and (b) an alternative that produced a stimulus that was followed by a higher probability of reinforcement (50%) but did not provide discriminative stimuli. They found a strong preference for the suboptimal alternative that produced discriminative stimuli.

Zentall and Stagner (2011a) explored the possibility that pigeons were choosing suboptimally because they found the uncertainty of reinforcement associated with the higher probability of reinforcement alternative to be aversive. They tested this hypothesis by manipulating the amount of food rather than the percentage of reinforcement. Thus, choice of the lower amount of reinforcement alternative resulted in a stimulus that signaled 10 pellets of food 20% of the time, whereas 80% of the time, that choice resulted in a stimulus that signaled no food (an average of two pellets of food). Choice of the higher amount of reinforcement alternative yielded one of two stimuli, each of which was followed by three pellets of food 100% of the time. With this task, the uncertainty previously associated with the higher probability of reinforcement alternative was removed, yet it still provided more reinforcement. In this case as well, pigeons showed a strong preference for the alternative with the lower amount of reinforcement. Thus, uncertainty associated with the higher probability of reinforcement alternative does not appear to play an important role in the suboptimal choice behavior.

The research suggested that pigeons were not basing their choice on the probability of reinforcement associated with each of the alternatives. Rather, they appeared to be choosing the alternative associated with the best conditioned reinforcer (i.e., with the stimulus that predicted 10 pellets) and discounting the high probability of getting the stimulus that predicted no reinforcement when they chose that alternative. Stagner et al. (2012) tested this hypothesis directly by giving pigeons a task in which choice of either alternative resulted in discriminative stimuli and, in each case, one of them was followed by reinforcement 100% of the time. However, that predictor of reinforcement appeared 20% of the time following choice of one alternative, whereas it appeared 50% of the time following choice of the other alternative. If, under these conditions, pigeons were sensitive to the overall probability of reinforcement, they should have chosen the alternative with the

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higher probability of reinforcement. However, Stagner et al. found that the pigeons were indifferent between the two alternatives, supporting the hypothesis that the pigeons' choice was based on the value of the conditioned reinforcer that followed the choice rather than the frequency of the conditioned reinforcer. Results such as these suggest not only that the probability of a win is less important than the value of win (when it occurs) but also that the probability of a loss is relatively unimportant. A similar effect has been reported with humans who are habitual gamblers (Blanco, Ibáñez, Sáiz-Ruiz, Blanco-Jerez, & Nunes, 2000).

One of the interesting findings in the human gambling literature is that the more similar a loss is to a win, the more humans are encouraged to continue gambling. This phenomenon, referred to as a *near-miss effect* (or, more properly, a *near-hit effect*), is formally defined as a failure that appears to come close to winning (Reid, 1986). For example, in the spin of a roulette wheel, if the ball misses the winning number by one slot, there is the sense of almost winning. Similarly, if one's lottery ticket is off by only one number, it feels like almost winning. Also, in a three-reel slot machine, a jackpot can be won by lining up three of the same symbols, one on each reel. However, two cherries and a bell, for example, represent a loss, but that combination is judged by many gamblers to be closer to a winning outcome than three stimuli that do not match—for example, a cherry, a bell, and a lemon.

Studies have shown that people prefer near hits to clear losses. Reid (1986) found that 18 out of 20 subjects agreed that near hits promoted more gambling behavior. Similarly, when MacLin, Dixon, Daugherty, and Small (2007) gave subjects a choice among three machines, one that gave near-hit trials 45% of the time, another that gave near hits 30% of the time, and the third that gave near hits 15% of the time, they generally preferred the machine that gave near-hit trials most often. Reid suggested that perhaps near hits are not viewed as losses but, rather, more like outcomes that are close to winning. Griffiths (1999) proposed that near hits encourage further game play because even though they represent losing, the gamblers must be doing something right. Langer (1975) proposed that the near hit gives gamblers the illusion of control. That is, getting close to winning suggests that there may be skill involved although it is a game of chance. This perception of control may result from games involving skill, such as shooting basketballs, in which near hits can provide feedback for improvement and on how to modify behavior on the next trial, but this would not be true in games of chance. Commercial gambling systems sometimes take advantage of the perceived value of coming close to winning by programming machines to provide more near hits to encourage further game play (Burbank, 2000). As one reviewer noted, the increased use of near hits may be even more common in machines used on cruise ships, because they operate in international waters where no governing agency has authority.

The near-hit phenomenon is of interest because it appears to be a counterintuitive effect. Although a near hit might gain conditioned reinforcing value from its similarity to a winning sequence, because it is a loss, its similarity to the winning sequence should also reduce the value of the conditioned reinforcer by way of generalization from the loss. For this reason, it would be informative to investigate the effect of near-hit trials on choice by animals.

Evidence has been found that nonhuman animals may also prefer alternatives associated with near-hit trials. For example, Winstanley, Cocker, and Rogers (2011) tested rats with an apparatus that resembled a slot machine. After three lights appeared sequentially, the rats could press a *collect* lever that rewarded them or imposed a time out when three lights did not appear. However, if any one of the three lights did not appear, the rats could press a *continue* lever that would advance directly to the next trial. Ideally, to avoid the time out, when one of the lights failed to appear, a rat should immediately press the continue lever. Results indicated that the rats did tend to press the collect lever more often on near-hit trials (when two of three lights came on) than on trials that indicated a clear loss (when two or three of the lights failed to come on). However, the results are more parsimoniously accounted for in terms of stimulus generalization, because the rats tended to make a collect response independently of which of the three lights failed to come on. That is, even if the first light failed to come on, indicating that it would be a losing trial, the rats tried to collect as often as when only the last of the three lights failed to come on.

In a related study, Scarf et al. (2011) found that for pigeons, near hits activated neurons in the same areas of the brain as wins did. But once again, although the activity was correlated with the number of matching stimuli, the results did not appear to differentiate between trials on which the nonmatching stimuli appeared early versus late in the trial, as might be expected if the buildup to near-hit trials was important. Thus, it may be that the physical similarity between win trials and certain loss trials can better account for the results found.

In the present experiments, we asked if pigeons would prefer trials on which the terminal link began with a stimulus that indicated it might be a win but, midway through the trial, the stimulus changed to a loss. Specifically, pigeons were given a choice between two alternatives, both of which involved discriminative stimuli and were associated with 50% reinforcement (Experiments 1 and 2) or 20% reinforcement (Experiments 3 and 4). One alternative, in addition to the typical positive stimulus (S+) and negative stimulus (S−) trials, contained near-hit trials in which the S+ that predicted food on other trials was shown for the first few seconds following choice of that alternative, and then the S+ switched to the S− that predicted the absence of food for the remainder of the trial. Choice of the other alternative was never followed by a near-hit trial, but it had the same number of reinforced and nonreinforced trials per session.

Given that both alternatives were associated with the same probability of reinforcement, a possible outcome of this study was that, like humans, the pigeons would show a preference for the alternative that produced near-hit-like trials. Alternatively, it might be that because both alternatives were associated with the same number of S+ stimuli always followed by reinforcement, the pigeons would be indifferent between the two alternatives (see Stagner et al., 2012). Finally, although the probability of reinforcement associated with the two alternatives was the same, nonreinforcement associated with the near-hit trials might serve to devalue the S+ trials, thus reducing the value of the near-hit alternative. That is, with the addition of near-hit trials starting out with the S+, choice of the near-hit alternative would now be followed by presentation of the S+, but not all of those presentations would be associated with reinforcement. In some respects, this procedure is more similar to the near miss with a lottery ticket, because the numbers on the near-miss lottery ticket match the winning number until the final number that does not match.

Experiment 1

Method

Subjects. The subjects were eight unsexed white Carneau pigeons that were retired breeders, 5–8 years old. Throughout the experiment, the pigeons were maintained at 85% of their free-feeding weight. They were individually housed in wire cages with free access to water and grit in a colony room that was maintained on a 12:12-hr light:dark cycle. The pigeons were cared for in accordance with University of Kentucky animal care guidelines.

Apparatus. The experiment was conducted in a BRS/LVE (Laurel, MD) sound-attenuating standard operant test chamber with inside measurements of 35 cm high, 30 cm long, and 35 cm across the response panel. The response panel in each chamber had a horizontal row of three response keys 25 cm above the floor. The rectangular keys (2.5 cm high × 3.0 cm wide) were separated from each other by 1.0 cm, and behind each key was a 12-stimulus inline projector (Industrial Electronics Engineering, Van Nuys, CA). The left and right projectors projected red, blue, green, and yellow hues (Kodak Wratten Filter Numbers 26, 38, 60, 9, respectively) and a black circle and plus sign on a white background. In each chamber, the bottom of the center-mounted feeder was 9.5 cm from the floor. When the feeder was raised, it was illuminated by a 28-V, 0.04-A lamp. Reinforcement consisted of 1.5 s of Purina (St. Louis, MO) Pro Grains. An exhaust fan mounted on the outside of the chamber masked extraneous noise. A microcomputer in an adjacent room controlled the experiment.

Procedure: Pretraining. Each pigeon was trained to peck each of four colors (red, green, yellow, and blue) and the plus and circle shapes on both side keys. One peck was required to each stimulus, followed by reinforcement. There were 12 trials of each type, for a total of 72 trials in each of two sessions.

Procedure: Training. In training, forced trials began with either the plus or circle shape stimulus presented on one of the side keys while the other side key remained dark. A single peck to the shape stimulus initiated a colored stimulus for 10 s. If the shape stimulus indicated that the near-hit alternative was in effect, on 50% of the trials, a peck replaced the shape with one color (e.g., red), and after 10 s, reinforcement was provided. On 25% of the trials, the shape stimulus was replaced with the second stimulus (e.g., green), and after 10 s, no reinforcement was provided. On the remaining 25% of trials, the shape stimulus was replaced by the red stimulus for 5 s, and the red stimulus was replaced by the green stimulus for the remaining 5 s. These trials were considered near-hit trials, and no reinforcement followed them. For this alternative, overall, reinforcement occurred 50% of the time.

If on forced trials the shape stimulus indicated that the non-near-hit alternative stimulus was in effect, on 50% of the trials, a peck replaced the shape stimulus with a third stimulus (e.g., blue), and after 10 s, reinforcement was provided. On the remaining 50% of the trials, a peck replaced the shape stimulus with the fourth stimulus (e.g., yellow), and after 10 s, no reinforcement was provided. Thus, for the non-near-hit alternative, reinforcement also occurred 50% of the time.

For all pigeons, randomly mixed among 64 forced trials (32 forced trials to each of the two alternatives) were 32 choice trials per session. These choice trials began with both plus and circle shape stimuli illuminated on the side keys. A single peck to a shape turned on one of the two stimuli associated with that alternative in the same proportion and with the same outcome as on forced trials. The unchosen shape key was darkened.

The side keys on which the two alternatives appeared were counterbalanced over trials, and the four key colors were counterbalanced over pigeons (to the extent possible). The intertrial interval was 10 s. All of the pigeons received 20 sessions of training. A schematic of the design of the experiment is presented in Figure 1.

Results

Pigeons were initially indifferent between the two alternatives, but they soon developed a preference for the alternative without the near-hit trials. The results of Experiment 1 appear in Figure 2. By the end of training, pigeons were choosing the near-hit alternative only 22.7% (95% confidence interval [CI] [8.21, 37.11]) of the time (pooled over the last five sessions). This preference was significantly below chance (50%), $t(7) = -4.47$, $p = .003$, Cohen's $d = 3.38$.

Discussion

In spite of the fact that the two alternatives represented equal probabilities of reinforcement, unlike humans, the pigeons appeared to prefer the alternative that did not include near-hit trials. That is, some of the nonreinforced trials initially produced a stimulus that on other trials was associated with reinforcement. However, when midway through the trial, the stimulus changed to the stimulus associated with the absence of reinforcement, the pigeons tended to avoid that alternative. Thus, it appears that presentation of near-hit trials devalues the stimulus that on other trials is associated with reinforcement. That is, 75% of the time, choice of the near-hit alternative resulted in an S+, but on only 67% of those trials did reinforcement follow. Thus, the S+ associated with the near-hit alternative was not as good a predictor of reinforcement as the S+ associated with the non-near-hit alternative, which was a perfect predictor of reinforcement.

If the near-hit trials devalue the S+ because of their similarity to the S+ and the absence of reinforcement associated with them, then one should be able to manipulate the degree to which they devalue the S+ by manipulating the duration of that stimulus on near-hit trials. That is, the more similar the near-hit trial is to an S+ trial, the greater should be the devaluation of the S+ by the near-hit trials. In Experiment 2, we trained one group of pigeons (Group 2–8) with near-hit trials on which the S+ was presented for only 2 s before it changed to the S− for the remaining 8 s.

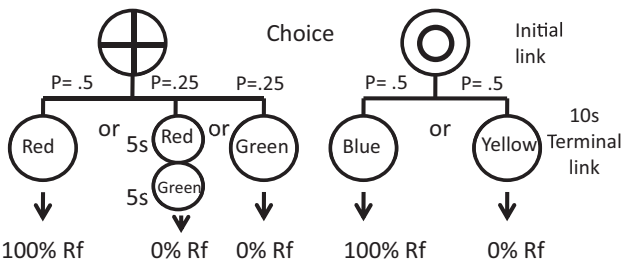

Figure 1. Design of Experiment 1. Rf = reinforcement.

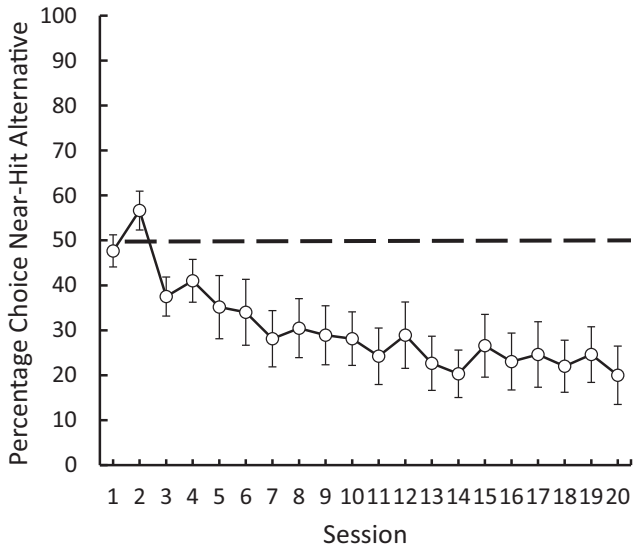

Figure 2. Results of Experiment 1: Percentage choice of the near-hit alternative as a function of training. Error bars represent standard errors of the mean.

Another group of pigeons (Group 8–2) was trained with near-hit trials on which the S+ was presented for 8 s before it changed to the S− for the remaining 2 s.

What characterizes near-hit trials for humans is their similarity to win trials. It is not until the last reel of a slot machine stops that the trial becomes a near-hit trial. If the similarity of the near-hit trials to the positive trials plays a role in the preference for the non-near-hit alternative, and it is the similarity of the near-hit trials to the positive trials that produces the preference for the non-near-hit alternative by pigeons, then Group 8–2 should show a greater preference than Group 2–8 for the non-near-hit alternative.

Experiment 2

Method

Subjects and apparatus. The subjects and apparatus were the same as those used in Experiment 1.

Procedure: Varied terminal link training. We randomly assigned the subjects from Experiment 1 each to one of two groups. For both groups, the shapes associated with the near-hit and non-near-hit alternatives were exchanged. For example, if the plus stimulus signaled the near-hit alternative in Experiment 1, it signaled the non-near-hit alternative in Experiment 2. The colors associated with near-hit and non-near-hit alternatives remained the same from Experiment 1, as did the contingencies of reinforcement associated with those colors. The only other procedural change in Experiment 2 was the manipulation of the duration of the two terminal link colors on near-hit trials. For Group 2–8, on near-hit trials, the color representing reinforced trials stayed on for 2 s and changed to the color representing nonreinforced trials for the remaining 8 s. On near-hit trials for Group 8–2, the color representing reinforced trials stayed on for 8 s and changed to the color representing nonreinforced trials for the remaining 2 s. A schematic of the design of the experiment is presented in Figure 3. All pigeons received 64 forced trials and 32 choice trials per session for a total of 60 sessions.

Results

Because the shapes associated with the near-hit and non-near-hit alternatives were reversed from Experiment 1, in which a strong preference for the non-near-hit alternative was found, initially both groups showed a preference for the shape associated with the near-hit alternative. However, as in Experiment 1, with training, both groups began to choose the non-near-hit alternative more often. After about 16 sessions of training, Group 8–2 began to prefer the non-near-hit alternative over the near-hit alternative. Although it took Group 2–8 somewhat longer, they too began to prefer the non-near-hit alternative (after about 40 sessions of training). For both groups, the percentage choice of the near-hit alternative as a function of sessions of training appears in Figure 4. On Session 60, Group 8–2 chose the near-hit alternative only 14.8% of the time, whereas Group 2–8 chose the near-hit alternative 44.5% of the time. When the data were pooled over the last five sessions of training, Group 2–8 (M = 45.6%, 95% CI [28.7%, 62.6%]) differed significantly from Group 8–2 (M = 24.0%, 95% CI [11.2%, 36.8]), $t(6) = 5.2$, $p = .002$, Cohen's $d = 4.25$. In addition, Group 8–2 chose the near-hit alternative significantly below chance, $t(3) = -13.93$, $p < .001$, Cohen's $d = 16.08$. And although Group 2–8 also chose the near-hit alternative below chance, the difference from chance did not reach statistical significance ($t < 1$).

Discussion

In Experiment 2, although neither group preferred the near-hit alternative, pigeons in Group 8–2 chose the near-hit alternative significantly less than did pigeons in Group 2–8. On near-hit trials,

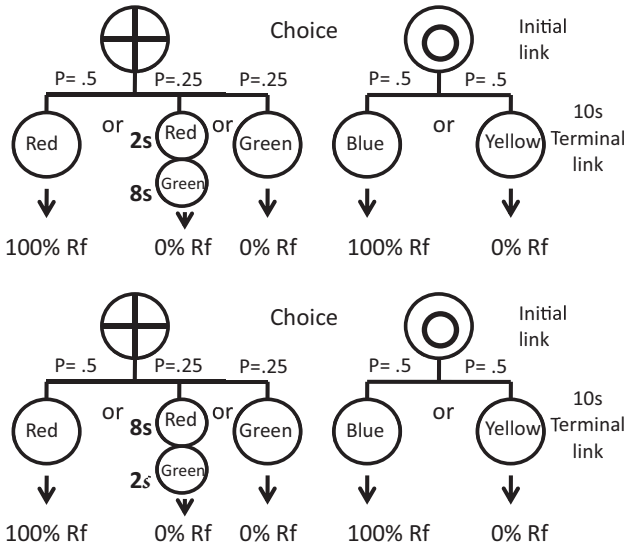

Figure 3. Design of Experiment 2 for Group 2–8 (top) and Group 8–2 (bottom). Colors were counterbalanced between subjects, and positions of shapes were counterbalanced over trials within sessions. Rf = reinforcement.

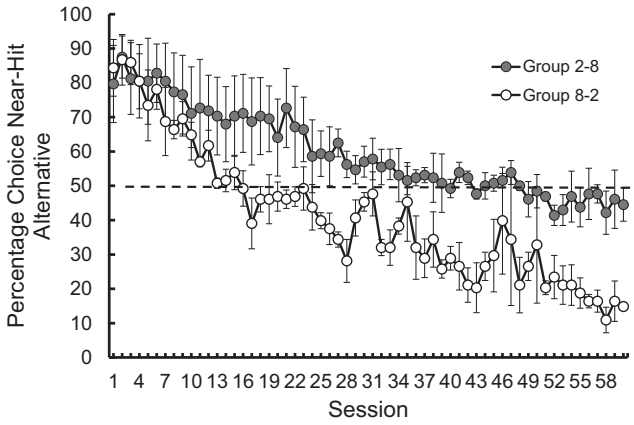

Figure 4. Results of Experiment 2: Percentage choice of the near-hit alternative as a function of training for pigeons in Group 2–8 and Group 8–2. All pigeons began with a preference for what appeared to be the near-hit alternative, because the pigeons were those used in Experiment 1 with the contingencies reversed. Error bars represent standard errors of the mean.

having the S+ (that on other trials predicted reinforcement) remain on for 8 s before switching to the S− appeared to be more aversive than having that stimulus remain on for only 2 s before switching to the S−. That is, on near-hit trials, the longer the signal for reinforcement remained on, the more that it appeared to devalue the S+.

This result is consistent with the hypothesis that the similarity of near-hit trials to S+ trials is responsible for avoidance of that alternative. In fact, to the degree that the near-hit trials were similar to the win trials, this would have devalued the ability of the win color to predict reinforcement. In spite of the fact that reinforcement was just as likely for choosing either of the two alternatives, the appearance of the stimulus associated with reinforcement following choice of the near-hit alternative predicted reinforcement only two-thirds of the time. In contrast, the appearance of the stimulus associated with reinforcement following choice of the non-near-hit alternative always predicted reinforcement.

Experiment 3

One difference between the procedure used in Experiments 1 and 2 and the typical near-hit procedure with humans is the fact that in the human procedure, there is typically no information provided by the initial stimulus presented (corresponding to the initial stimulus in the terminal link of the present experiments). In Experiments 1 and 2, choice of either alternative resulted in a stimulus that provided immediate information about the outcome of the trial (although in the case of the near-hit alternative, that information was not only unreliable but appeared to devalue the conditioned reinforcer). A better analogue to the near-hit procedure with humans might be the appearance of an ambiguous stimulus that could result in reinforcement without devaluing the positive stimulus. Thus, on near-hit trials, instead of the immediate appearance of the color that signaled reinforcement or nonreinforcement, in Experiment 3, choice of the near-hit alternative resulted in a neutral stimulus that appeared for 8 s before changing to either the positive or the negative stimulus for the last 2 s of the terminal link (comparable to the information provided by the last reel of a slot machine or the last number on a lottery ticket).

In Experiment 3, on all trials, choice of the near-hit alternative was followed by presentation of a unique ambiguous stimulus that 20% of the time was followed by a positive stimulus signaling reinforcement and 80% of the time was followed by a negative stimulus signaling the absence of reinforcement. Thus, the unique ambiguous stimulus was comparable to a near-hit trial, the first two matching reels, with the final stimulus or reel serving to clarify the ambiguity. Choice of the non-near-hit alternative was followed immediately by the 10-s presentation of a positive stimulus signaling reinforcement 20% of the time or by a negative stimulus signaling the absence of reinforcement 80% of the time.

If pigeons make choices on the basis of the immediate appearance of the stimulus associated with reinforcement (the conditioned reinforcer), they should once again prefer the non-near-hit alternative. There is suggestive evidence that delaying the onset of the conditioned reinforcer does, in fact, reduce preference for the suboptimal choice. Using a related but somewhat different design, Belke and Spetch (1994) interposed a 5-s separation between the initial (choice) stimuli and the terminal link stimuli that followed and found that pigeons no longer chose suboptimally (50% signaled reinforcement over 100% reinforcement) but now showed a preference for the optimal alternative. However, if the appearance of the stimulus associated with the absence of reinforcer (the presumed conditioned inhibitor) inhibits choice of that alternative, its immediate appearance may inhibit choice of the non-near-hit alternative.

A similar prediction of a preference for the near-hit alternative can be inferred from *delay-reduction theory* (Fantino & Abarca, 1985), according to which, a stimulus that predicts reinforcement sooner in its presence than in its absence will become a conditioned reinforcer. That is, how good is the stimulus at reducing the delay to reinforcement relative to its absence? According to delay-reduction theory, a short stimulus that is immediately followed by reinforcement should reduce the delay to reinforcement more than a longer stimulus, because the onset of the longer stimulus appears farther from reinforcement than the onset of the shorter stimulus. By that reasoning, pigeons should prefer the alternative that results in presentation of the positive stimulus 2 s before the end of a trial over the alternative that results in presentation of the positive stimulus 10 s before the end of a trial.

Method

Subjects and apparatus. The 10 subjects in Experiment 3 were similar to but not the same as those from Experiments 1 and 2. They were housed and maintained as were the pigeons in Experiments 1 and 2. The apparatus was the same as that used in Experiments 1 and 2.

Procedure: Pretraining. Subjects were given one session of 60 trials consisting of a vertical or horizontal line orientation, the initial links that would be used in training, with each appearing equally on the right and left key. A single peck to this initial link stimulus resulted in reinforcement followed by a 10-s intertrial interval. Subjects were given this training for two sessions. The probability of reinforcement was then decreased to 50% following

a response to each initial link for two sessions, and then it was decreased to 20% for two additional sessions. On the following session, subjects were given one 60-trial session with all of the sequences that would follow each initial link in training. Following a response to the vertical line orientation, 20% of the time, a blue stimulus would appear and remain on for 10 s, followed by reinforcement. The other 80% of the time, a yellow stimulus would appear for 10 s, followed by reinforcement. Following a response to the horizontal stimulus, a black dot on a white background would be illuminated for 8 s; it would change to a red stimulus for 2 s 20% of the time and be followed by reinforcement or change to a green stimulus for 2 s 80% of the time and be followed by reinforcement. The colors associated with the initial link stimuli were counterbalanced over subjects.

Procedure: Training. Training was similar to the last session of pretraining, with the following exceptions: The color that appeared 80% of the time following a response to either initial link stimulus no longer resulted in reinforcement. Thus, the probability of reinforcement following each initial link was reduced to 20%. The only important difference in the choice of the two alternatives was when the color indicating whether reinforcement would follow or not would appear. Choice of the near-hit alternative resulted in presentation of the ambiguous dot stimulus for 8 s, followed by presentation of the signal for reinforcement (20% of the time) or its absence (80% of the time), whereas choice of the non-near-hit initial link resulted in the immediate 10-s presentation of the signal for reinforcement (20% of the time) or its absence (80% of the time). Further, during training, there were 40 forced trials and 20 choice trials. On forced trials, only one alternative was available (20 trials of each, counterbalanced within session for position of the initial stimulus). On choice trials, both alternatives were available. The design of Experiment 3 appears in Figure 5. Subjects were given 25 sessions of training.

Results

Once again, the pigeons showed an almost immediate strong preference for the non-near-hit alternative. Within eight sessions of training, the pigeons preferred the non-near-hit alternative almost 90% of the time, and they showed a similar preference for the remainder of training. The training data for Experiment 3 are presented in Figure 6. When the data from the last five sessions of training were pooled, subjects chose the near-hit alternative only 7.5% of the time (95% CI [−4.5%, 15.8%]). A t test indicated that the preference for the non-near-hit alternative was significantly different from chance (50%), $t(9) = 11.74$, $p < .001$, Cohen's $d = 7.83$. These results suggest that subjects had a strong preference for the outcome that was not associated with a near-hit or ambiguous outcome.

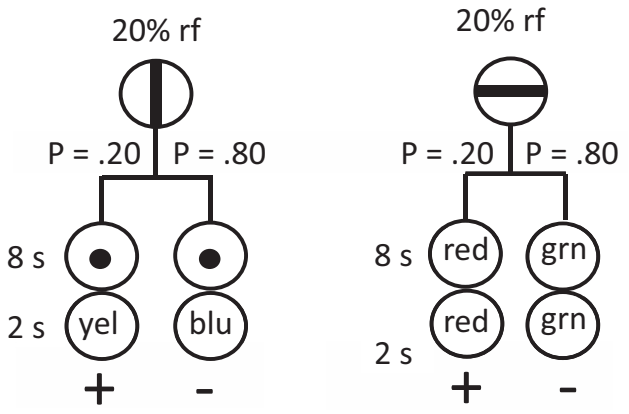

Figure 5. Design of Experiment 3. rf = reinforcement; yel = yellow; blu = blue; grn = green.

Discussion

In Experiments 1 and 2, we found that pigeons avoided an alternative that resulted in some trials that started with an S+ but changed to an S− (comparable to a near-hit trial) over an alternative with the same number of reinforced trials but no near-hit trials. The purpose of Experiment 3 was to ask if the results of Experiments 1 and 2 were attributable to the fact that the near-hit trials devalued the S+ trials because of their similarity to the S+. In Experiment 3, to avoid the similarity between S+ trials and near-hit trials, we introduced an ambiguous cue, a dot, for 8 s following a response to the near-hit initial link that ended with presentation of the S+ (followed by reinforcement) or the S− (followed by the absence of reinforcement). On the one hand, delaying the appearance of the S+ should have reduced the conditioned reinforcing value of choice of the near-hit alternative. On the other hand, according to delay-reduction theory, the relatively short duration of the S+ immediately preceding reinforcement should have increased the conditioned reinforcing value of the S+.

The results of Experiment 3 suggest that the immediacy of the appearance of the S+ following choice of the non-near-hit alternative had a greater effect on initial link choice than whatever advantage there was to the shortened duration of the S+ associated with the near-hit alternative. Once again, in contrast with the apparent preference for near-hit trials shown by humans (MacLin et al., 2007), it appears that pigeons avoid the alternative that results in near-hit-like trials.

Experiment 4

Although the results of Experiment 3 suggest that pigeons avoid the alternative that results in near-hit trials because, on near-hit trials, the conditioned reinforcers that follow choice of that alternative are delayed, it is also possible that the non-near-hit alternative was preferred because on all trials involving the conditioned reinforcer, it was presented for the full 10 s, whereas the conditioned reinforcer appeared for only 2 s on near-hit trials. To control for this possibility, in Experiment 4, choice of the non-near-hit alternative resulted in the immediate appearance of the S+ or S−, but for only 2 s, followed immediately by presentation of the ambiguous dot stimulus for the remaining 8 s. If the longer duration of the conditioned reinforcer was responsible for the preference for the non-near-hit alternative, then pigeons in Experiment 4 should not prefer the non-near-hit alternative. If, however, preference for the non-near-hit alternative in Experiment 3 resulted from the immediacy of the conditioned reinforcer following choice of the non-near-hit alternative, then the pigeons in Experiment 4 should have a preference for the non-near-hit alternative.

In Experiment 4, we used the same pigeons as in Experiment 3, but the initial signals for the near-hit and non-near-hit alternatives

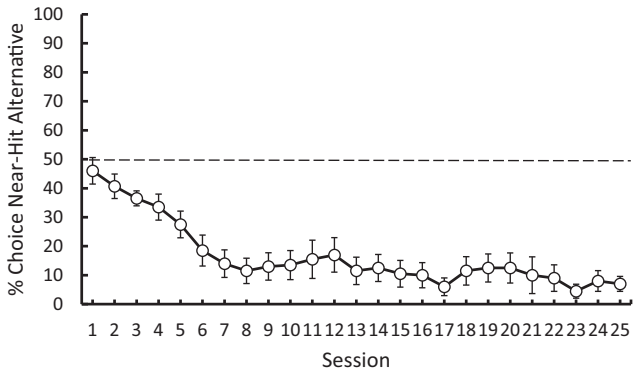

Figure 6. Results of Experiment 3: Percentage choice of the near-hit alternative as a function of training. Error bars represent standard errors of the mean.

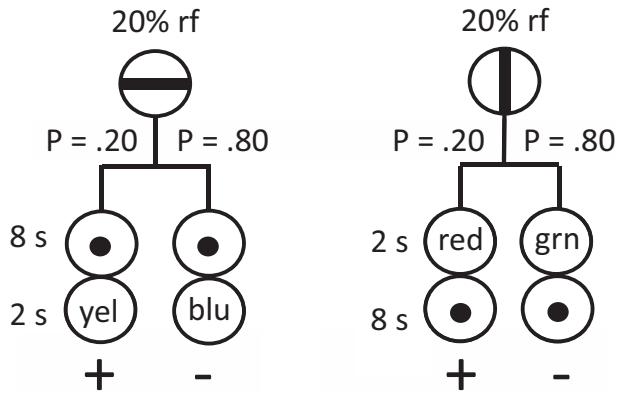

Figure 7. Design of Experiment 4. rf = reinforcement; yel = yellow; blu = blue; grn = green.

were interchanged. Thus, as a result of their performance in Experiment 3, the pigeons were expected to begin training with a strong initial preference for the near-hit alternative, but if they continued to prefer the non-near-hit alternative, we expected the initial link preference to reverse with training.

Method

Subjects and apparatus. Subjects were those from Experiment 3. One of the subjects from Experiment 3 died early during Experiment 4. The data from this subject were not included in any of the analyses. The apparatus was the same as that used in Experiment 3.

Procedure. For all subjects, the initial vertical and horizontal line cues that signaled the near-hit and non-near-hit alternatives were exchanged, but the colors associated with the near-hit and non-near-hit alternatives remained the same. In addition, both colors associated with the non-near-hit alternative, which appeared immediately after a response to the initial stimulus associated with the non-near-hit alternative, were presented for only 2 s, followed immediately by the black dot on a white background for the remaining 8 s. The number of forced and choice trials per session remained the same as in Experiment 3, as did the reinforcement percentages associated with each alternative. The design of Experiment 4 appears in Figure 7. Testing continued for 35 sessions.

Results

Because the pigeons began training in Experiment 4 with the initial link stimuli reversed from what they were in Experiment 3, initially the pigeons appeared to show a strong preference for the near-hit alternative; however, within a few sessions of training, they reverted to their preference for the non-near-hit alternative. By Session 10 of training, the pigeons were beginning to show a preference for the non-near-hit alternative. Over the last five sessions of training, subjects chose the near-hit alternative only 12.0% of the time (95% CI [1.0%, 23.0%]), significantly below chance (50%), $t(8) = 8.01$, $p = < .0001$, Cohen's $d = 3.02$. The results of Experiment 4 appear in Figure 8.

Discussion

The results of Experiment 4 confirm the results of Experiment 3 (and support the results of Experiments 1 and 2). Unlike humans, pigeons do not appear to prefer (and actually avoid) alternatives that provide near-hit-like trials. Further, the results of Experiment 3 did not depend on the longer (10-s) duration of the S+ following choice of the non-near-hit alternative as compared with the shorter (2-s) duration of the S+ following choice of the near-hit alternative. In Experiment 4, when the duration of the S+ following choice of either alternative was controlled, a strong preference for the non-near-hit alternative was still found.

General Discussion

The results of the present experiments indicate that, unlike humans, pigeons do not prefer an alternative that provides near-hit trials (an alternative that provides an immediate S+ that changes to an S−, as in Experiments 1 and 2, or an alternative that provides an ambiguous stimulus that in time becomes an S+ or S−, as in Experiments 3 and 4).

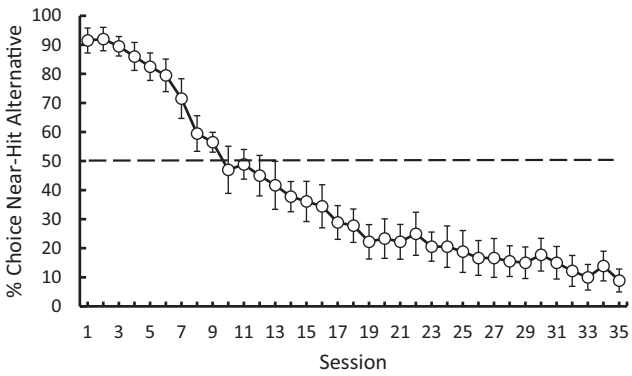

Figure 8. Results of Experiment 4: Percentage choice of the near-hit alternative as a function of training. The pigeons began with a preference for the near-hit alternative, because the pigeons were those from Experiment 3 with the contingencies reversed. Error bars represent standard errors of the mean.

Although the procedure used in Experiments 3 and 4 came closer to providing a true near-hit event than the procedure used in the Experiments 1 and 2, it may have lacked a characteristic of the near hit experienced in many human gambling experiences. In a three-reel slot machine, when the first reel stops, the exposed symbol provides little information. The near-hit experience requires that when the second reel stops, it exposes a symbol that matches the first. In the pigeon task used in Experiments 3 and 4, one has to imagine that the dot represents the matching outcome of the first two reels, and one has to wait until 8 s have passed to determine if reinforcement will come. The near-hit procedure in the current experiments (especially the procedure used in Experiments 3 and 4) may be more similar to the near-hit event that occurs when all numbers but the last one on a lottery ticket match the winning numbers, because there is ambiguity about the outcome until the last number fails to match.

It is also possible that avoidance of the near-hit alternative by pigeons occurred because of the large number of near-hit trials used in Experiments 3 and 4. Had only a fraction of the trials been near-hit trials, avoidance of the near-hit alternative might have been greatly reduced, or the near-hit alternative might have been preferred. Alternatively, had only a few of the trials been near-hit trials, one could have argued that there were not sufficient near-hit trials to produce a preference for the near-hit alternative.

Earlier research found that pigeons show the same tendency to choose low-probability, high-payoff outcomes (gambling) over more optimal high-probability, low-payoff outcomes (not gambling) as do problem gamblers (e.g., Laude et al., 2014; Stagner et al., 2012; Stagner & Zentall, 2010; Zentall & Stagner, 2011a, 2011b). But the present research suggests that, unlike humans, pigeons may not be attracted to near-hit outcomes. Thus, it is likely that the two phenomena result from different processes. In earlier research, we have suggested that the attraction to low-probability, high-payoff outcomes comes from the high value placed on highly predictive conditioned reinforcers (winning) without considering their frequency (e.g., Stagner et al., 2012), together with the relative ineffectiveness of stimuli associated with the absence of reinforcement (Laude et al., 2014). But what then is responsible for the apparent value that humans give to near-hit trials?

Several authors have suggested that humans' attraction to the near hit comes from the illusion that a near-hit is closer to a hit than it is to a loss (Griffiths, 1999; Reid, 1986), and Langer (1975) proposed that the near-hit event gives gamblers the illusion of control. After all, in many games of skill, even if one loses, getting closer to success does represent an improvement in the skill. Apparently, pigeons do not suffer from this illusion, or at least they do not suffer from this illusion with this task, in which a near hit does not indicate that one is getting closer to a win, because the outcomes are totally random.

The preference for near-hit outcomes by humans may result from the large number of skill tasks in which humans tend to engage. It would be interesting to know if giving an animal a large number of skill tasks, in which getting close to success represents a higher probability of success, might alter an animal's avoidance of near-hit outcomes in tasks in which skill plays no role.

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