Sunk Cost: Pigeons (*Columba livia*), Too, Show Bias To Complete a Task Rather Than Shift to Another

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The sunk cost effect involves the bias to stay with an alternative because one has already invested resources, even when there is a better alternative available. In a series of experiments, at various points during a 30-peck requirement, pigeons (*Columba livia*) could choose between completing the response requirement (at a different location in Experiment 1 or the same location in Experiments 3 and 4) and switching to a constant number of pecks. In three experiments, the pigeons showed a bias to complete the pecks already started, even when that required more pecking. We also demonstrated that the bias depended on the initial investment and was not produced merely because the pigeons preferred a variable alternative over a fixed alternative. The deviation from optimal choice suggests that pigeons show a bias similar to the sunk cost effect in humans.

Keywords: sunk cost, suboptimal choice, pigeons

Sunk cost involves an expenditure of resources that has occurred. The sunk cost effect/fallacy occurs when one allows the amount already invested to justify the investment of more resources. For example, one may sit through a film that one does not like because to leave would be to waste one's investment of the price of the ticket. But, in so doing, one is spending additional resources—one's time. The sunk cost fallacy can be seen as a product of escalation of commitment. Economists studying human's tendency to continue to invest in pursuits that seem unlikely to end profitably find that when individuals make an initial investment decision themselves they are more likely to continue to invest in a foundering project. The size of the initial investment also plays a role in escalation. Those who invest more initially are more likely to continue to invest in the future (Staw, 1981). The persistence of individuals at a task that they are failing has also been shown to be greater when they are closer to their goal and the investment is higher (Rubin & Brockner, 1975).

Staw (1981) proposed that individuals are likely to escalate their commitment for several reasons, including an effort to salvage a project and prove that their previous commitment was rational, part of an external justification process, or an adherence to norms of consistency, especially when they are in a leadership position. In his review of the literature, Brockner found that the decision to invest further in a foundering pursuit is also governed, at least in part, by decision makers' "unwillingness to admit they were mis-

taken" (Brockner, 1992, p. 41). This is often explained, using Festinger's (1957) theory of cognitive dissonance, as a product of peoples' unwillingness to admit to themselves that their past decision was incorrect.

An additional explanation for this puzzling behavior may be that people have strong misgivings about wasting resources, a disposition that economists call *loss aversion* (Novemsky & Kahneman, 2005). And such behavior is sufficiently common in humans that it has spawned the colloquialism, "throwing good money after bad" (Arkes & Blumer, 2000).

Behavioral economists often point to the sunk cost effect as evidence that humans do not always behave rationally (Arkes & Blumer, 2000). They cite the sunk cost effect as a prime example of maladaptive behavior—the sort of mistake a nonhuman animal would not make because animals are more sensitive to reinforcement contingencies and are less likely to use abstract cultural rules to govern their behavior. When reviewing several examples of suggested sunk cost fallacies in animals, Arkes and Ayton (1999) argued that, in each case, the behavior had a more rational basis because the initial investment was not truly a sunk cost. They conclude that it is only humans who demonstrate a true sunk cost fallacy. Arkes and Ayton contend that sunk cost fallacies occur when adult humans overgeneralize a cultural "don't waste" rule because they are strongly loss-averse. They further posit that this effect does not occur in children and nonhuman animals because both are less likely than adult humans to use abstract rules and because animals are more sensitive to the reinforcement contingencies that they encounter (animals have been more strongly selected for their ability to choose optimally).

Navarro and Fantino (2005, Experiment 1) examined the sunk cost effect in pigeons in which, on each trial there was a 0.50 probability of a small number (10) of pecks required for reinforcement and a decreasing probability that many more responses (40, 80, or 160) would be required. At any time, the pigeon could choose to start a new trial, thereby potentially getting a trial with a smaller number of pecks to reinforcement. When the number of

pecks already made was signaled, the pigeons generally started a new trial after making 10 pecks and before making 40 pecks. However, if the number of pecks made was not signaled, the pigeons generally persisted and did not start a new trial. In the case of the signaled pecks, the alternatives were relatively clear. If, after making 10 pecks, reinforcement was not provided and they continued with the current trial, they would have to make at least 30 more pecks (and perhaps as many as 150 more pecks), whereas if they started another trial, there was a 50% chance that reinforcement would be provided for 10 additional pecks. However, in the case of the unsignaled pecks, they would be uncertain how many pecks had been made and, thus, how many additional pecks would have to be made, so the pigeons persisted rather than starting a new trial. The unsignaled case may be more analogous to the typical economic sunk cost effect with humans because there is generally uncertainty about the likelihood that persistence will not pay off.

Recently, Watanabe (2009) investigated the sunk cost effect in pigeons using a somewhat different procedure. After training pigeons to peck 30 times to one color for food and 10 times to another color for food, Watanabe had them make an initial investment of a variable number of pecks and then gave them a choice between continuing to complete the response requirement of 30 pecks and switching to the stimulus with the 10-peck requirement. For example, after pecking one key 10 times, he gave the pigeons a choice to stay with that key and make the remaining 20 pecks, or to move to the other key where only 10 pecks (a constant from trial to trial) would be required. He asked if the pigeons would have a bias to complete the larger response requirement because they had already made an investment of pecks to that alternative (a sunk cost) rather than choose to switch to the lower peck requirement.

Watanabe (2009) found that three of the four pigeons showed a preference for completing the higher peck requirement, in spite of the fact that switching to the other alternative would have required fewer responses. However, in Watanabe's procedure, it may be that staying with the key already pecked was less costly than switching to the other key because switching required moving (to the other key) whereas staying did not.

The current experiments investigated the sunk cost bias in pigeons while equating for the time and effort required for staying or switching. In the first experiment, pigeons were required to make an initial investment by pecking the center key and then to move to a side key to either complete the 30-peck response requirement or to move to the other side key to respond a fixed 15 times on all trials. Specifically, after making a variable number of pecks (an investment of 5, 10, 15, 20, or 25 pecks) to the center key, the key went dark and the pigeon was given a choice between the two side keys. It could choose to stay with the same color (presented on one side key) and complete the balance of the 30-peck requirement (either 25, 20, 15, 10, or 5 more pecks, respectively, depending on the initial investment) or change to the other color (presented on the other side key) for a constant 15 pecks. Extensive training was provided to ensure that the contingencies of reinforcement were adequately experienced. Also, the number of trials on which switching and staying was optimal was equated, and trials on which there was no difference in the number of pecks required to complete the 30 pecks or switch to the 15 pecks were included. In Experiment 1 we asked if the pigeons would show a bias for completing the original response requirement.

Experiment 1

Method

Subjects. The subjects were eight unsexed White Carneaux pigeons (*Columba livia*), ranging from 5 to 8 years of age. They were retired breeders purchased from the Palmetto Pigeon Plant (Sumter, SC). The pigeons were kept on a 12:12-h light/dark cycle and maintained at 80% of their free-feeding body weight. The pigeons were individually housed in wire or combination sheet metal and Plexiglas cages. They had free access to grit and water and were cared for in accordance with the University of Kentucky's animal care guidelines. All pigeons had previous experience in unrelated studies involving simple simultaneous discriminations and matching-to-sample discriminations.

Apparatus. The experiment was conducted in a standard LVE/BRS (Laurel, MD) sound-attenuating operant chamber. The inside measurements of the chamber were 32.0 cm high, 32.0 cm across the response panel, and 28.0 cm from the response panel to the back wall. Three 2.5-cm $\times$ 2.5-cm square response keys were aligned horizontally on the response panel and separated by 0.8 cm. The bottom edges of the response keys were 25.5 cm from the wire mesh floor. A 12-stimulus in-line projector (Industrial Electronics Engineering, Van Nuys, CA) was used, with 28 V, 0.1 A lamps (GE 1820) mounted behind each response key. The response keys were illuminated with red and green hues (Kodak Wratten filters nos. 26 and 60). A rear-mounted feeder provided mixed grain reinforcement (Purina Pro Grains, St. Louis, IL), with the feeder illuminated through a 5.1-cm $\times$ 5.5-cm aperture centered horizontally on the response panel and vertically midway between the response keys and the floor of the chamber. Reinforcement consisted of 1.5-s access to mixed grain. The experiment was controlled, and data collected, by a computer (Compac Presario SR5710Y) with a Med Associates (St. Albans, VT) interface, located in an adjacent room. An exhaust fan mounted on the outside of the chamber masked extraneous noise.

Procedure.

Pretraining. All pigeons initially received pretraining sessions in which they were required to peck 30 times for reinforcement on the colored key assigned to them as the 30-peck color (either green or red counterbalanced over subjects) or 15 times to the other color. In each 90-trial session, each color was presented 15 times at each of the three response key locations. At the end of the pretraining session, 10 additional trials were presented in which the pigeons were given a choice between the 30-peck and the 15-peck colors on the two side keys. Trials were separated by a 10-s intertrial interval (ITI). Each pigeon received this training until it met a criterion of two consecutive days at 90% or greater choice of the 15-peck color on the 10 choice trials.

Training. On half of the trials, the 30-peck color was presented on the center key. After 5, 10, 15, 20, or 25 pecks to the center key (randomly determined), the center key was turned off and one of the side keys was presented with the 30-peck color for the balance of pecks (the initial investment plus side key pecks equaled 30 pecks) followed by reinforcement. On the other half of the trials, responding to the 30-peck color on the center key for 5, 10, 15, 20, or 25 pecks resulted in presentation of the 15-peck color on one of the side keys. Fifteen pecks to that key was followed by reinforcement. There were 80 trials per session, an equal number

with each of the five initial center-key investments, and each single-variable or constant alternative on the left or on the right (four trials of each unique trial type). Each pigeon moved on to testing when it completed each of three consecutive sessions in less than 1 hr. This criterion ensured that each pigeon would progress through the session at a reasonable rate.

Testing. On test trials, the pigeons were first presented with the high response color on the center response key. After 5, 10, 15, 20, or 25 pecks to the center response key, the center key was turned off and both side keys were illuminated. The 15-peck color always required 15 pecks for reinforcement, and the 30-peck color required the balance of 30 pecks less the initial (center key) investment. After a single peck to either side key, the other side key was turned off. In each testing session there were 30 test trials as well as 30 training trials (an initial investment of 5, 10, 15, 20, or 25 pecks followed by the balance of 30 pecks to the same color on one or the other side key, or followed by the 15-peck color on one or the other side key), randomly presented. Pigeons experienced 90 sessions of testing, one session per day, six days a week.

Results

When the percentage of choices to stay with the stimulus of the initial investment at each level (5, 10, 15, 20, and 25 initial pecks) was averaged over the last 10 test sessions (to ensure that the pigeons had gained sufficient experience with the task to learn about the relation between the initial investment and the consequences of choosing either response alternative), on average, the pigeons tended to complete the 30-peck requirement (stay with the initial color), even when that choice was not optimal, and to do so required investing more work or time than would have been required had they chosen to switch to the fixed, 15-peck alternative (see Figure 1). At the point at which the same number of additional responses was required for either alternative (15 pecks to stay with the 30-peck alternative vs. 15 pecks to switch to the other alternative), the mean choice to stay with the 30-peck color was 70.6% (SD = 17.7). This choice was significantly different from chance (50%), $t(7) = 2.67$, $p < .05$. When 20 additional responses were required to complete the 30-peck requirement but only 15 pecks

were required to complete the alternative peck requirement, the pigeons chose to make 20 pecks almost half of the time, 43.8% (SD = 17.6).

To obtain an estimate of this response bias, a measure of sensitivity to the difference in response requirements (or discriminability) was calculated that was independent of the response bias. To obtain this discriminability measure, the difference of the preference scores from that of an ideal detector (diamonds in Figure 1) represented by the same absolute difference between the two alternatives was calculated. Thus, when the number of pecks required to complete the 30-peck requirement was either 5 or 25 pecks, the difference from alternative 15 pecks was equal ($N = 10$), and when the number of pecks required to complete the 30-peck requirement was either 10 or 20 pecks, the difference from 15 pecks was also equal ($N = 5$). The average difference from ideal was then added to the ideal when the number of pecks required to complete the 30-peck requirement was less than 15, and it was subtracted from the ideal when the number of pecks required to complete the 30-peck requirement was greater than 15 (see Figure 1, open circles). When the number of pecks required to complete the 30-peck requirement was equal to 15, the unbiased preference score was plotted as 50%. Then, to obtain a measure of the sunk cost bias, choice at each level was tested against this sensitivity function. Those comparisons revealed a reliable difference from an unbiased response after 10 pecks, $t(7) = 1.96$, $p < .05$, as well as after 15 pecks $t(7) = 3.2$, $p < .05$, but not after 20 pecks, $t(7) = 1.87$, $p > .05$. Differences after 5 pecks or 25 pecks were not expected because of floor and ceiling effects, respectively.

The data from individual pigeons was similar to the group function for five of the eight pigeons whose average choice to stay at the expected indifference point (15 vs. 15 pecks) was 83.0% and ranged from 75% to 90% (see Figure 2). One pigeon appeared to be insensitive to the manipulation, instead preferring one side key regardless of the color that appeared there. Counterbalanced presentation left its choices close to 50% at all levels of initial responses to the center key. The two remaining pigeons performed somewhat more optimally, choosing to complete the 30-peck requirement at the expected indifference point 42% and 57% of the time, as well as generally switching after 5 or 10 pecks and staying after 20 and 25 pecks.
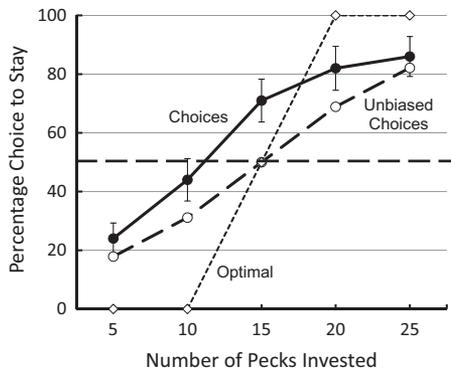
Discussion

When the number of responses required to the two alternatives was the same, the deviation from chance indicated the presence of a bias representative of a sunk cost effect. However, one could argue that when the cost of staying versus switching was equal, there was no additional cost to staying over switching. More compelling evidence that the pigeons showed a suboptimal bias occurred after 10 pecks of initial investment. In this case, the number of pecks required for staying was 20 and the number of pecks required for switching was only 15, and there was a reliable bias to continue with the 30-peck color (43.8% worse that ideal and 12.8% worse than the unbiased sensitivity). One could argue, perhaps, that the near indifference the pigeons showed when they had invested 10 pecks occurred because they were unable to discriminate between 15 and 20 required pecks to complete the trial. The fact that they showed a strong preference to complete the

Figure 1. Experiment 1: Choice to stay and complete the 30-peck alternative (Stay) as a function of the number of responses already made (Invested). Pigeons' choices (solid lines, filled circles), optimal choice (dotted lines, diamonds), and unbiased sensitivity function (dashed lines, open circles).
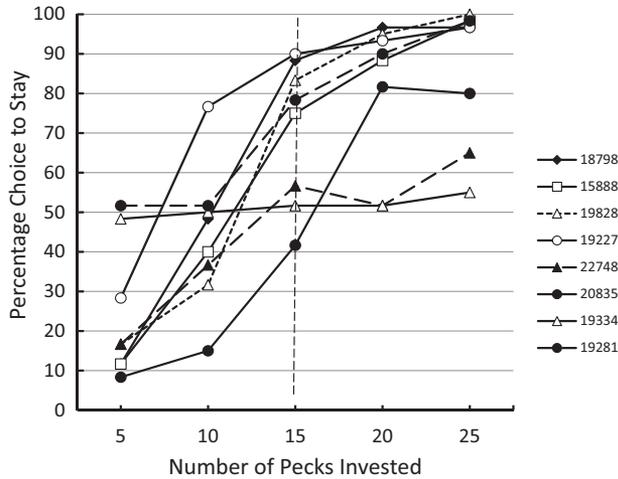
Figure 2. Experiment 1: Choice data for individual pigeons. Choice to complete the 30-peck alternative (Stay) as a function of the number of responses already made (Invested). Vertical dotted line represents the point of equal response requirement.

number of pecks required for the 30-peck requirement, when only 15 pecks were required to complete the trial, suggests that the indifference at 15 initial pecks resulted from a bias to complete the 30-peck schedule.

The present research suggests that pigeons, like humans, show a bias to stay with an initial investment; however, there may be an alternative explanation for the bias to choose to complete the 30-peck schedule—the variability in the number of pecks required over trials to the complete the 30-peck schedule. Specifically, when the overall rate of reinforcement is equal, there is evidence that animals typically prefer variable schedules of reinforcement over fixed schedules (see, e.g., Fantino, 1967). Presumably, this preference results from the nonlinear function relating the value of reinforcement to delay of reinforcement (i.e., shorter than average delay of reinforcement has a greater positive value than longer than average delay of reinforcement has a negative value). More technically, there is evidence that the delay discounting function (the value of a reinforcement plotted against the delay of reinforcement) is hyperbolic (see, e.g., Green & Myerson, 1996).

Experiment 2

One reason that the pigeons in Experiment 1 showed a preference for completing the 30-peck requirement rather than changing to the fixed 15-peck requirement may have been that they had a preference for the variability of responding associated with that choice. There is evidence, for example, that animals tend to be risk (variability) prone when it comes to delay of reward (Kacelnik & Bateson, 1996). In the case of the present experiments, completing the 30-peck requirement meant that they would have to peck between 5 and 25 times, and they might prefer that over pecking a certain 15 times, in spite of the fact that, on average, it would require the same number of pecks (see Cicerone, 1976). If the pigeons in Experiment 1 had developed a preference to complete the 30 pecks because of the variability of the peck requirement to complete the trial once the initial investment had been made, they

should continue to prefer the variable response requirement associated with that alternative over the fixed response requirement even if there were no initial investment made. On the other hand, if, in the absence of an initial investment, the pigeons showed a tendency to choose to complete the 30-peck requirement at below chance levels (because based on training, it would suggest that the alternative associated with completion of the 30 pecks required more pecks than the constant 15-peck alternative), it would suggest that the results of Experiment 1 reflected a true bias based on the initial investment.

Method

Subjects. The subjects were the eight pigeons used in Experiment 1.

Apparatus. The apparatus was the same as in Experiment 1.

Procedure. The day after completing Experiment 1, the pigeons began Experiment 2. Sessions consisted of 30 trials each of two trial types (forced and choice). On choice trials, the pigeons were presented with the 30-peck color (counterbalancing assignment from Experiment 1 was preserved) on one of the two side keys and the 15-peck color on the other. Unlike Experiment 1, there was no initial investment on the center key. Reinforcement occurred after 5, 10, 15, 20, or 25 pecks to the variable-peck-requirement key (as determined by random selection of trial type) or 15-peck alternative. After a single peck to either key, the other side key was extinguished. On forced trials, only one side key was illuminated—either the variable alternative, requiring 5, 10, 15, 20, 25 pecks (randomly determined), or, on the other half of the trials, the fixed 15 color. Reinforcement occurred when the peck requirement was met. As in Experiment 1, there was a 10-s ITI. There were seven sessions of testing, one session per day.

Results

Percent responses to the variable alternative were averaged over pigeons for each of the seven sessions. Choice of the variable alternative on each of the test sessions is presented in Figure 3. On Session 1, the mean choice of the variable alternative was 26.2% (*SD* = 18.7), and it rose on each successive session to 61.9%
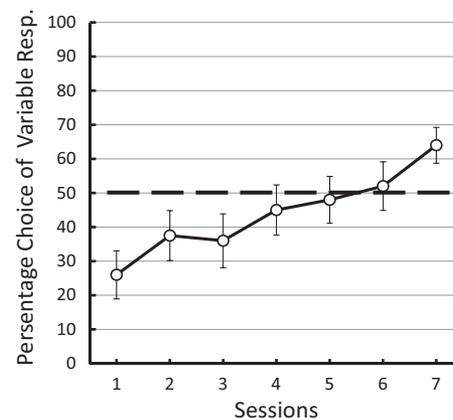

Figure 3. Experiment 2: Mean choice of the variable response requirement in the absence of an initial investment.

(*SD* = 14.99) on Session 7. When the critical first session means were compared to chance responding (50%) with a *t* test, the difference was statistically significant, *t*(7) = 3.36, *p* < .001, indicating that the pigeons' choice of the variable alternative was significantly below chance. A repeated measures ANOVA performed on the data, with sessions as the factor, indicated that there was a significant effect of session, *F*(6, 42) = 9.02, *p* < .05. A planned comparison indicated that the linear trend was also significant, *F*(1, 7) = 27.08, *p* < .05.

Discussion

The initial preference for the fixed 15-peck alternative, when no initial investment was required, indicates that a preference for the variable-peck alternative was not responsible for the preference for the number of pecks required to complete the 30-peck-requirement alternative found in Experiment 1. If the choice bias found in Experiment 1 had resulted from consideration of the number of pecks remaining to the 30-peck alternative, it would have suggested that, in Experiment 2, in the absence of an initial investment, the choice would have been between 30 and 15 pecks, and the 15-peck alternative should have been preferred, which it was.

When no initial investment was required, the pigeons initially demonstrated a preference for the 15-peck alternative. Thus, it was not the case that, in Experiment 1, the pigeons had an inherent preference for the variable alternative over the fixed alternative, as would be predicted if the pigeons had been risk prone (Gilby & Wrangham, 2007; Kacelnik & Bateson, 1996). However, consistent with past research (Fantino, 1967), over sessions, the pigeons did develop a preference for the variable over the 15-peck schedule. Thus, in Experiment 2, with experience, the pigeons learned that the alternative was no longer the number of pecks required to complete the 30-peck requirement, in which the original investment was always zero pecks, but, rather, a variable number of pecks (between 5 to 25), revealing a tendency for the pigeons to be risk prone.

Experiment 3

The procedures used in Experiment 1 involved making an investment on the center key and, if selected, completion of the 30-peck requirement on one of the side keys. It was assumed that presenting the color of the center key (investment) on one of the side keys would serve as a cue to complete the 30-peck requirement. However, there is evidence that there is little generalization between a color on one key and the same color on a different key (Lionello-DeNolf & Urcuioli, 1998, 2000). In that research, it was found that if pigeons are trained on matching-to-sample, with the samples presented on the center key and comparisons on the side keys, when the samples are moved to one of the side keys, matching accuracy greatly declines. Although it is not clear that it is necessary to have the color of the investment key and completion of the 30-peck key match, it may be important that the location of the two stimuli be the same.

The purpose of Experiment 3 was to ask if we could replicate the effect found in Experiment 1 when the investment key and the completion of the 30-peck key were the same. Thus, in Experiment 3, the investment key was one of the side keys and (after pecking the center key to equate for distance traveled) the pigeons could choose to return to that key to complete the 30 pecks or switch to the other side key to make the constant number of pecks. More specifically, to ensure that the "cost" of staying and switching were the same in Experiment 3, when the investment pecks had been made, the investment key went off and the center key came on (white). A single peck to the center key was required to reilluminate the investment key, where the remainder of the 30 pecks would be required, and the alternative side key, where the fixed 15 pecks would be required.

Method

Subjects. The subjects were four experimentally naïve pigeons but otherwise similar to those used in Experiments 1 and 2.

Apparatus. The apparatus was a Med Associates (St. Albans, VT) test chamber (ENV-007) in a sound attenuating cubicle (ENV018V), with three circular response keys (2-cm diameter) separated by 5 cm and a grain feeder. The left and right response keys could project red and green lights, and the center response key could project white. Reinforcement consisted of 2-s access to mixed grain. The experiment was controlled by a Med Associates interface located in an adjacent room. A speaker in the chamber provided white noise at 70 dB.

Procedure. Each pigeon was trained to peck the left (green) and right (red) response key. The number of pecks required for reinforcement was gradually increased to 30 pecks. There were six kinds of training trails (10 of each), randomly intermixed:

1. *30-peck trials*: With the left green key lit, responding was reinforced for making 30 pecks.

2. *10-peck trials*: With the right red key lit, responding was reinforced for making 10 pecks.

3. *Choice trials with no investment*: With both keys lit, a single response to either key extinguished the unchosen key. Responses on the left green key were reinforced on a fixed 30-peck schedule, whereas responses on the right key were reinforced on a fixed 10-peck schedule.

4. *Choice trials with an fixed 10-peck investment*: The left green key was lit and 10 pecks were required to turn it off. After 0.5 s, the center white key was turned on and a single peck turned it off and turned on the left green and right red keys. Twenty additional pecks to the left green side key, or 10 pecks to the right red key, were required for reinforcement. The first peck to either side key turned off the other side key.

5. *Choice trials with a fixed 15-peck investment*: The left green key was lit and 15 pecks were required to turn it off. After 0.5 s, the center white key was turned on and a single peck turned it off and turned on the left green and right red keys. Fifteen additional pecks to the left green side key, or 10 pecks to the right red key, were required for reinforcement.

6. *Choice trials with a fixed 20-peck investment*: The left green key was lit and 20 pecks were required to turn it off. After 0.5 s, the center white key was turned on and

a single peck turned it off and turned on the left green and right red keys. Ten additional pecks to the left green side key, or 10 pecks to the right red key, were required for reinforcement. Training consisted of a minimum of 30 sessions or until stable choice was attained.

Results

When there was no initial investment, all of the pigeons preferred the fixed 10-peck alternative. However, when there was any investment at all, there was a general preference for the number of pecks required to complete the 30-peck requirement. The data for individual pigeons is presented in Figure 4.

When the number of pecks invested was 10 and the number of pecks required to complete the 30-peck requirement was 20, all of the pigeons preferred the number of pecks required to complete the 30-peck requirement ($M = 71.2\%$), but not significantly so, $t(3) = 2.82$, $p = .07$. However, when the number of pecks invested was either 15 or 20 and the number of pecks required to complete the 30-peck requirement was 15 or 10, respectively, all of the pigeons showed a strong preference for the number of pecks required to complete the 30-peck requirement ($M = 88.8\%$ and 95.5%, respectively), $t(3) = 20.53$, $p = .0003$, and $t(3) = 34.39$, $p < .0001$, respectively.

In addition, following their initial investment, the pigeons appeared to be sensitive to the relative number of pecks that they would be required to make to obtain reinforcement. Even considering only those trials on which an initial investment was made, the pigeons showed an increasing preference for the number of pecks required to complete the 30-peck requirement as the number of pecks required for that alternative decreased. A one-way repeated measures ANOVA performed on the three trial types involving an initial investment (10, 15, and 20 pecks) indicated that there was a significant effect of increasing investment, $F(2, 6) = 9.18$, $p = .001$.

Discussion

A very strong preference to complete the schedule already started was found in Experiment 3. This occurred in spite of the
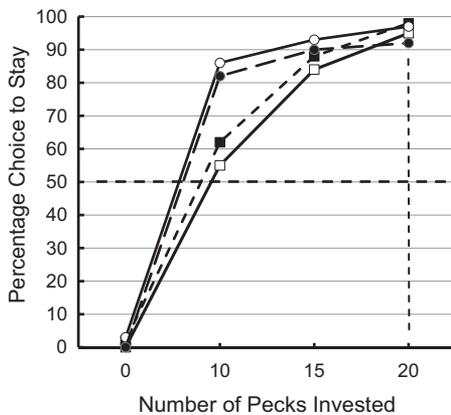

Figure 4. Experiment 3: Choice data for individual pigeons. Choice to complete the 30-peck alternative (Stay) as a function of the number of responses already made (Invested). Vertical dotted line represents the point of equal response requirement.

fact that, except in the case of an initial investment of 20 pecks, the pigeons would have been fed sooner (and with less effort) had they opted for the fixed 10-peck alternative. And even in the case of the initial investment of 20 pecks, when the pigeons should have been relatively indifferent between the two alternatives because the number of pecks to obtain reinforcement was equal for the two alternatives, the pigeons showed a 95.5% preference to complete the schedule that they started.

The preference for the number of pecks required to complete the 30-peck requirement found in Experiment 3 was somewhat greater than that found in Experiment 1. Apparently, allowing the pigeons to return to the location at which they had made their initial investment strengthened their preference to complete the 30-peck schedule, compared with the procedure in Experiment 1, in which the initial investment occurred on a different key from completion of the 30-peck schedule.

It should be noted as well that, in Experiment 3, choice to complete the 30-peck schedule never resulted in a shorter time (or fewer pecks) to reinforcement. That is, unlike in Experiment 1, in which the optimal strategy to complete the trial with the fewest pecks depended on an estimation of the number of pecks already made, in Experiment 3, it would have been optimal to always choose the fixed 10-peck schedule. Yet clearly the pigeons did not do this. The only condition in which the pigeons consistently chose the fixed 10-peck alternative was when there was no initial investment. That is when the choice was between the 30 pecks and 10 pecks. The fact that the pigeons chose to make 10 pecks when there was no initial investment suggests that the earlier preference for the number of pecks required to complete the 30-peck requirement did not result merely from the variability in responses required to it over trials. Clearly, the preference for the 30-peck color resulted from the investment that the pigeons made prior to the choice.

Experiment 4

The stronger bias found in Experiment 3 than in Experiment 1 appeared to result from the ability of the pigeons to complete the number of pecks required to complete the 30-peck requirement on the key to which they had made their initial investment. The purpose of Experiment 4 was twofold. First, we wanted to replicate the strong results of Experiment 3. Second, we wanted to further rule out the possibility that the preference for the number of pecks required to complete the 30-peck requirement resulted, in part, because that schedule was variable (over trials), whereas the fixed 10-peck schedule was not. The procedure used in Experiment 2 offers one means of determining whether the initial investment affected choice of the side-key alternatives. Another approach involves maintaining the initial investment but eliminating the correlation between the initial investment and the number of additional pecks required to the alternative requiring the larger number of pecks. In Experiment 4, there were two groups of pigeons. For the correlated group, the initial investment was 0, 10, 15, or 20 pecks, and the choice was between the number of pecks required to complete the 30-peck requirement and the fixed 10-peck requirement. For the uncorrelated group, the initial investment was also 0, 10, 15, or 20 pecks, but the number of pecks to complete the 30-peck alternative was 30, 20, 15, or 10 pecks, randomly determined, and did not depend on the initial investment.

Method

Subjects. The subjects were eight pigeons similar to those used in Experiment 3.

Apparatus. The apparatus was the same as that used in Experiment 3.

Procedure. The pigeons were trained as were the pigeons in Experiment 3, with the exception that for four of the pigeons, the number of pecks required to the green stimulus for reinforcement following an initial investment of 0, 10, 15, or 20 pecks was randomly selected from 10, 15, 20, or 30 pecks. The number of pecks required to the red stimulus continued to be 10 pecks on all trials.

Results

The results for the pigeons in the correlated group were very similar to the results for the pigeons in Experiment 3. When there was no investment, all of the pigeons preferred the fixed 10-peck alternative; however, when there was any investment at all, there was a general preference for the number of pecks required to complete the 30-peck requirement. The results for the correlated group appear in Figure 5.

When the number of pecks invested was 10 and the number of pecks required to complete the 30-peck requirement was 20, all of the pigeons preferred to complete the 30-peck requirement (M = 76.5%), but, once again, not significantly so, $t(3)$ = 2.82, p = .07. However, when the number of pecks invested was either 15 or 20 and the number of pecks required to complete the 30-peck requirement was 15 or 10, respectively, all of the pigeons showed a strong preference to complete the 30-peck requirement (M = 87.8% and 95.8%, respectively), $t(3)$ = 14.74, p = .0007, and $t(3)$ = 41.26, p < .0001, respectively.

If one considers trials with an initial investment, although there was some increase in the preference to complete the 30-peck requirement, a one-way repeated measures ANOVA indicated that the preference did not differ significantly as a function of the number of pecks invested, $F(2, 6)$ = 3.23, p = .11.
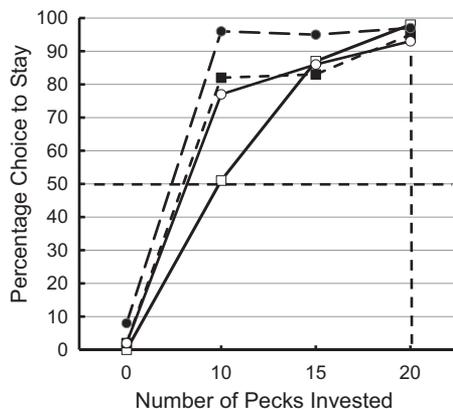

Figure 5. Experiment 4, Correlated group: Choice data for individual pigeons. Choice to complete the 30-peck alternative (Stay) as a function of the number of responses already made (investment). Vertical dotted line represents the point of equal response requirement.

The results for the uncorrelated group were quite different. Regardless of the prior investment, all of the pigeons showed a strong preference for the 10-peck requirement. Thus, when the investment did not predict the number of pecks required to complete the 30-peck requirement, it was never preferred. The results for the uncorrelated group appear in Figure 6.

Discussion

The results of Experiment 4 confirm the findings from Experiment 3. When the pigeons in the correlated group were able to return to the location at which they had made their initial investment, they showed a strong preference to do so, even though they could have obtained reinforcement somewhat faster by choosing the 10-peck alternative. This finding was particularly striking in the case of an initial investment of 10 pecks. On those trials, all of the pigeons showed some preference to make the 20 pecks required by returning to the key where they had made their initial investment rather than choosing the alternative key that would have required only 10 pecks.

The results for the uncorrelated group further confirm the results of Experiment 2 by showing that the pigeons' preference to complete the 30-peck requirement over the 10-peck alternative did not result from the fact that the number of pecks required to complete the 30-peck requirement was variable whereas the number of pecks required to the 10-peck alternative was fixed. When the initial investment did not predict the number of pecks required to complete the 30-peck requirement, all of the pigeons showed a strong preference to make 10 pecks.

General Discussion

In three experiments, we found that pigeons had a strong tendency to choose to complete the 30-peck requirement rather than choose the lower fixed response alternative. This effect was particularly strong in Experiments 3 and 4, in which the pigeons could complete the 30-peck requirement on the key on which they made the initial investment.

If the pigeons in the present experiments had optimized their effort and delay to reinforcement, one can see, in Figure 1, the degree to which the pigeons should have chosen to complete the 30-peck requirement or shift to the fixed response requirement, given the number of center-key pecks already made. That is, they should have consistently chosen the smaller number of responses to complete the trial and they should have been indifferent when the number of responses to complete the trial was the same for the two alternatives. However, they clearly did not.

The results of Experiments 2 and 4 further confirm that the preference to complete the 30-peck requirement did not result from the fact that the required number of pecks for that alternative to complete the trial varied over trials and that pigeons tend to prefer variable over fixed schedules of reinforcement. In Experiment 2, when the pigeons were tested without an initial investment, they preferred the 10-peck alternative, as if they had been given a choice between the 30 pecks and 10 pecks. Similarly, in Experiment 4, when the number of invested pecks did not predict the number of additional pecks required for the variable response alternative, the pigeons showed a consistent preference for the 10-peck alternative.
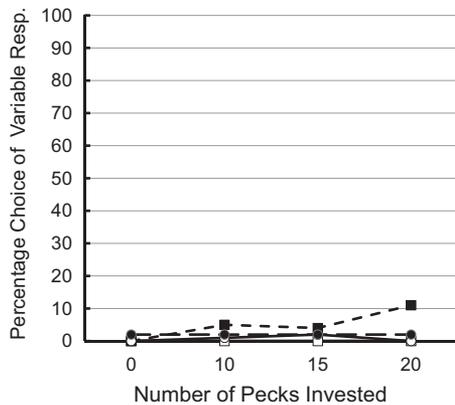
Figure 6. Experiment 4, Uncorrelated group: Choice data for individual pigeons. Choice of the variable response requirement as a function of the number of responses already made (Invested).

One explanation for the bias observed in Experiment 1 is that the pigeons valued the reinforcement following greater effort more than the reinforcement resulting from less effort, a phenomenon sometimes referred to as within-trial contrast (Zentall, 2007). For example, Friedrich and Zentall (2004) found that when pigeons had been trained to peck many times to obtain food from one location and only once to obtain food from a different location, they showed an increased preference to obtain food from the location for which they were required to peck more often for reinforcement (see also Clement, Feltus, Kaiser, & Zentall, 2000).

Kacelnik and Marsh (2002) found a similar effect in European starlings. Birds were required to make a high-effort investment consisting of 16 m of flight to attain one colored key, which, when pecked, resulted in reinforcement. A second color was paired with a low-effort condition requiring only 4 m of flight for identical reinforcement. When the starlings were given a choice between the two colors without having to make any investment of flight (a preference test), the majority of the birds preferred the color that was associated with the high-effort investment.

The within-trial contrast effects reported by Friedrich and Zentall (2004) and Kacelnik and Marsh (2002) were found under conditions in which the effort required to obtain the conditioned stimuli was experienced in training but differential effort was not required on test trials, whereas in the present research, the pigeons actually chose an alternative that required more pecking. The two procedures appear most similar when, in the sunk cost experiment, the number of pecks made in the initial investment meant that the number of pecks needed to complete the 30-peck requirement was equal to the number of pecks required if the pigeon switched to the other alternative.

Perhaps a better example of the suboptimal choice found in the present experiments is the contrafreeloading effect, in which animals will work to obtain food when identical food that does not require work is freely available (Neuringer, 1969). In one experiment, when gerbils were given the choice of digging through sand to obtain seeds or of eating seeds from a bowl that required no effort, they preferred to eat seeds that required an investment of effort by digging through the sand (Forkman, 1991). Although contrafreeloading has often been viewed as suboptimal, Inglis and

Ferguson (1986) have suggested that it results from a predisposition that animals have to obtain environmental information. That is, by working for food, they can learn the contingencies for obtaining food should the free-food resource become depleted. For example, for animals that showed a contrafreeloading effect, when subsequently tested in extinction (with food from the best alternative no longer available), because they had been sampling the other alternatives, they reliably chose the second best alternative (Bean, Mason, & Bateson, 1999).

The sunk cost phenomenon studied in the present experiments may result from a mechanism similar to what is responsible for a phenomenon studied in humans known as the endowment effect, ownership effect, or status quo bias (Samuelson & Zeckhauser, 1988). This effect is demonstrated by humans when they give greater value to an object that is in their possession than the same object that is not already theirs (Knetsch, 1989). Furthermore, there is evidence that nonhuman animals also show evidence of an endowment effect (Brosnan et al., 2007; Lakshminaryanan, Chen, & Santos, 2008). For example, primates will prefer to keep a treat that was given to them rather than exchange that treat for an equally preferred (or more preferred) treat. This phenomenon is likely to result from the more general tendency of animals (including humans) to be loss averse. Monkeys prefer to be offered one piece of apple but on half of the trials receive a second piece of apple than to be offered two pieces of apple but on half of the trials receive only one piece of apple (Chen, Lakshminaryanan, & Santos, 2006). That is, although the outcome was the same, the monkeys preferred to receive more than they were shown rather than less than they were shown (but see Silberberg et al., 2008 for an alternative explanation of this effect).

In the present sunk cost experiment, one could posit that the initial investment would be lost by switching to the alternative with the fixed number of pecks and that the pigeons were averse to losing that investment. If the sunk cost effect has a similar basis as the endowment effect, it suggests that the pigeons treat the initial investment as a form of endowment or ownership and thus give greater value to "maintaining possession" of the response requirement associated with completion of the 30 pecks.

Alternatively, one could view the sunk cost effect from an ecological perspective. It is possible that under natural conditions, animals that forage in patches may have a predisposed tendency to stay in a patch longer than would be optimal. This could occur because the food available in the current patch may be more certain (even if on average it may have less food) than the uncertain food available in a new patch. However, what little experimental research has been done with pigeons in an operant context suggests that, if anything, the opposite may be true. That is, pigeons given a choice between a depleting schedule of reinforcement and a constant (known) number of responses tend to start with the more profitable, depleting schedule but switch to the constant schedule somewhat earlier than would be expected given the rate of return from both schedules (Bhatt & Wasserman, 1987). However, in nature, the choice to leave a patch must be balanced by the uncertainty of the time to locate another patch (travel time) and the uncertain availability of food at that new patch, whereas in the Bhatt and Wasserman (1987) procedure, the travel time was minimal and the number of pecks required in the alternative patch was constant. Thus, it may be that the Bhatt and Wasserman

(1987) study is not a good analogy for animals foraging in a natural environment.

Although it is not entirely clear what behavioral mechanism is responsible for the bias found in the present experiments, the convergent evidence provided by the present experiments suggests that pigeons show a bias that is not unlike the sunk cost effect that has been reported with humans (Arkes & Blumer, 2000). Thus, it is likely that the sunk cost effect found in humans has a basic behavioral/biological basis rather than being merely a culturally based overgeneralization of a "don't waste" rule.

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