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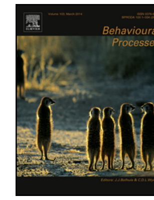

A good time to leave?: the sunk time effect in pigeons

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ABSTRACT

Persistence in a losing course of action due to prior investments of time, known as the sunk time effect, has seldom been studied in nonhuman animals. On every trial in the present study, pigeons were required to choose between two response keys. Responses on one key produced food after a short fixed interval (FI) of time on some trials, or on other trials, no food (Extinction) after a longer time. FI and Extinction trials were not differently signaled, were equiprobable, and alternated randomly. Responses on a second Escape key allowed the pigeon to terminate the current trial and start a new one. The optimal behavior was for pigeons to peck the escape key once the duration equivalent to the short FI had elapsed without reward. Durations of the short FI and the longer Extinction schedules were varied over conditions. In some conditions, the pigeons suboptimally responded through the Extinction interval, thus committing the sunk time effect. The absolute duration of the short FI had no effect on the choice between persisting and escaping. Instead, the ratio of FI and Extinction durations determined the likelihood of persistence during extinction

1. Introduction

In humans, the sunk time effect is a familiar experience. Often we leave a party later than at a good time to leave, or continue to watch a movie that does not improve. The more general phenomenon is the sunk cost effect in humans, the tendency to persist in a suboptimal course of action when an alternative, more profitable option, is available (Arkes and Blumer, 1985). Nonhuman animals, including pigeons and rats, also commit the sunk cost effect (Avila-Santibañez et al., 2010; Macaskill and Hackenberg, 2012a, 2012b; Magalhães et al., 2012; Navarro and Fantino, 2005). In these studies, the subject can make a variable number of responses on one key or lever to obtain food. They are also able to respond on a second, concurrently available "escape" key or lever to terminate an unfavorable trial, and start a new one. When the conditions on a particular trial are unfavorable, the optimal strategy is to choose the escape key. In contrast, the suboptimal strategy is to persist – the sunk cost effect.

The sunk cost effect can occur with an explicit choice between outcomes (Magalhães and White, 2013, 2014a; Pattison et al., 2012; Piedad et al., 2006) and in the absence of cues signaling the type of trial in effect (Navarro and Fantino, 2005). It depends on the probabilities associated with each work requirement, as well as the values of each work requirement to food and the difference between them (Avila-Santibañez et al., 2010; Macaskill and Hackenberg, 2012a, 2012b; Navarro and Fantino, 2005). Other variables that affect the degree of the sunk cost effect are the cost of escaping *vs.* the cost of persisting (Macaskill and Hackenberg, 2012a, 2012b); the effort required to escape (Magalhães et al., 2012); and the prior history of the subject (Macaskill and Hackenberg, 2012a; Navarro and Fantino, 2005). Additionally, the greater the amount invested, the larger the sunk cost effect (Magalhães and White, 2014a).

The sunk time effect in nonhuman animals has seldom been studied. In a recent study by Magalhães and White (2014b), pigeons chose between two concurrently available keys. On one key (the "food key"), two Fixed-Interval (FI) schedules were arranged, and on a second "escape" key, a response terminated the current trial and started a new one, analogous to the procedure described above to study the sunk cost effect in pigeons and rats. One FI was longer than the other, and the shorter FI was always more probable on any given trial. For most conditions, these intervals were not differentially signaled. The result of interest was that pigeons tended to persist in a suboptimal course of action by continuing to respond through the longer FI, even when it was replaced by a long interval

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which did not end in reward (extinction), a result consistent with the sunk time effect. Magalhães and White showed that persistence in extinction tended to occur even when the pattern of food-key responding indicated that the intervals were discriminated, consistent with temporal discriminations in mixed fixed-interval schedules (Leak and Gibbon, 1995; Whitaker et al., 2003, 2008). It was unclear from the data reported by Magalhães and White, however, whether the important variable determining persistence was the absolute duration of the short FI schedule, or the ratio of durations between the short and long intervals. For example, did the pigeons escape from the extinction interval when it became obviously longer than the duration of the short interval (a discrimination of absolute durations), or when the ratio of long to short durations reached a critical point? The ratio of durations was a possible determinant of the moment of escape because pigeons are capable of discriminating ratios of time intervals (Fetterman et al., 1989).

The aim of the present experiment was to examine the effect of the ratio of short FI and long extinction intervals on the sunk time effect. Research on timing suggests that the relative difference rather than the absolute difference between intervals determines the discrimination between durations (Leak and Gibbon, 1995). However, if the absolute duration of the short interval is the key determinant of the sunk time effect, we might expect overall higher persistence with longer short intervals. To answer this question, we manipulated both the absolute duration of the short intervals and the ratio of durations of short to long. We arranged several ratios of short/long intervals: 1:16, 1:8, 1:4, 1:3 and 1:2, for two durations of the short FI.

2. Method

2.1. Subjects

Three homing pigeons (*Columba livia*), labeled E2, E3, and E4, were maintained at least at 85% of their free feeding body weight. All pigeons had prior experience with concurrent-chains procedures (Beeby and White, 2013). The pigeons were weighed prior to their daily experimental session, with those underweight receiving supplementary food after the session. The pigeons were individually housed in a colony room illuminated on a 12-hour light and dark cycle supplemented by natural light. Grit and water were continuously available in the home cages.

2.2. Apparatus

Three identical custom-built experimental chambers were 32 cm high, 35 cm wide and 35 cm deep. Each chamber had a grid floor and a front intelligent panel containing a row of three 2.1-cm diameter plexiglass response keys, 21 cm above the floor and spaced 6 cm apart (center to center). They could be lit with red, green, yellow and white light. Only right and center keys were used. Sufficiently strong (>0.15 N) pecks to an illuminated key produced a relay click. A hopper in an aperture 12.5 cm below the center key could provide 3-s access to wheat. A lamp inside the aperture and above the hopper was lit when wheat was available. The chambers were enclosed in an external box equipped with a fan that provided ventilation and masking noise. Events were controlled and recorded by a PC running Med-PC® for Windows, in an adjacent room.

2.3. Procedure

Owing to their prior experience, the pigeons were directly transferred to the present procedure. Experimental sessions were conducted 7 days a week, approximately at the same time of the day. Each session terminated when 80 rewards were earned or when 60 min had elapsed, whichever happened first. There was no limit on the number of trials in each session. Trials were separated by 1-s intertrial intervals (ITI) during which the experimental chamber was dark and all keys inoperative.

Table 1
Percentage of persistence in Extinction trials (interval durations for conditions are in s) and number of sessions in each condition for each bird.

							No. of sessions		
Phase	Condition	FI (s)	Extinction (s)	E2	E3	E4	E2	E3	E4
1	1	8	128	0	1	0	15	15	15
	2	8	64	0	1	3	15	18	24
	3	8	32	4	4	22	17	15	21
	4	8	16	94	88	53	16	18	38
2	5	2	32	0	0	1	17	15	15
	6	2	16	1	0	6	15	15	15
	7	2	8	3	6	11	16	24	18
	8	2	4	86	37	99	16	15	22
3	9	8	128	0	2	1	10	10	12
	10	8	24	6	68	32	27	27	24
	11	2	32	0	9	2	10	10	10
	12	2	6	37	20	93	15	15	16

Each trial started with both the center key (Food key) and the right key (Escape key) being lit. Two schedules were in effect on the food key, a short FI or a long Extinction schedule. Completion of the FI schedule turned off both keys and activated the hopper for 3 s, followed by the ITI, whereas at the end of the Extinction interval, both keys were turned off and the ITI started. Both FI and Extinction schedules were presented in a pseudo-random order, with equal probabilities. The escape key was concurrently available and could be pecked at any time during the trial. A peck on the escape key turned off the food key, and a second peck turned off the escape key and initiated the ITI after which a new trial started. Three phases, each with four conditions, were run (see Table 1). In Phases 1 and 2, the ratio of the FI/Extinction durations was manipulated while maintaining the FI at a fixed duration. In Phase 3, both FI duration and the ratios of the FI/Extinction durations were manipulated. Conditions 1 and 5 were replicated in Conditions 9 and 11 respectively (Table 1).

With few exceptions, experimental conditions were run for at least 15 sessions, and birds changed condition after meeting the following stability criterion. The number of escape responses from extinction was taken as a percentage of the total number of trials in a session. Performance was stable if this measure for each of the last 5 sessions was within ±2.5% of the mean percentage for the last 5 sessions. If the stability criterion had not been met, the pigeon continued in the same condition until the criterion was met or for a maximum of 40 sessions, after which pigeons changed to the next condition and data from the last five sessions were used. Table 1 shows the order of exposure to the different conditions which was the same for all pigeons, and the number of sessions completed by each pigeon in each condition.

2.4. Data analysis

Data analyses were based on responses summed over the last 5 sessions of each condition. Four response measures were calculated: percentage of persistence (=100 − percentage of escape responses) in the extinction trials (percentage of escape from extinction was calculated by taking the number of escape responses from the extinction trials as a percentage of the total number of extinction trials), latencies to escape in the extinction trials, Hit rate and False Alarm (FA) rate. These last two measures were derived from Signal Detection Theory analysis (Macmillan and Creelman, 2005). Hit rate was calculated by dividing the number of escapes in extinction trials by the total number of extinction trials. It was