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THE ROLE OF DISCRIMINATIVE STIMULI IN THE SUNK COST EFFECT

*EL PAPEL DE ESTÍMULOS DISCRIMINATIVOS EN
EL EFECTO DE COSTO HUNDIDO*

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ABSTRACT

We employed a behavior-analytic analog of the sunk cost effect in which all trials started out with a short expected ratio to an imaginary monetary reward, but some trials assumed a longer expected ratio part way through the trial. Subjects had the (preferable) option of “escaping” the trial if the longer expected ratio had come into effect in order to bring on a new trial that again had a short expected ratio. With a between-subjects design we tested whether the presence of discriminative stimuli correlated with the expected ratios would affect escaping behavior. In one condition, such stimuli were present; in the other condition, they were absent. Subjects persisted significantly more in the condition where discriminative stimuli were absent.

Key words: Sunk Cost Effect, escalation, discriminative stimuli, choice.

RESUMEN

Se empleó un análogo analítico-conductual del efecto de costo hundido, en el cual todos los ensayos iniciaron con una razón esperada corta respecto a una recompensa monetaria imaginaria, pero algunos ensayos adquirieron

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una razón esperada más larga durante parte del ensayo. Los sujetos tenían la opción (preferible) de “escapar” del ensayo si la razón esperada más larga estaba en efecto, para iniciar un nuevo ensayo que de nuevo tuviera una razón esperada corta. Con un diseño entre sujetos, se probó si la presencia de estímulos discriminativos correlacionados con las razones esperadas afectarían la conducta de escapar. En una condición, tales estímulos estaban presentes; en la otra condición, estaban ausentes. Los sujetos persistieron significativamente más en la condición en la cual los estímulos discriminativos estaban ausentes.

Palabras clave: Efecto de costo hundido

The sunk cost effect is the increased tendency to persist in an endeavor once an investment of money, time, or effort has been made. This effect appears to apply to two different decision contexts, known as adoption decisions and progress decisions. The effect is of interest to psychologists because, in the case of both types of decisions, sunk costs may lead people to behave in a non-optimal manner. For example, adoption decisions involve the choice of which of several already-purchased items to consume. The sunk cost effect is manifested in the adoption decision by the consumption of the most expensive item despite it having a utility less than or equal to any of the less-expensive items (Arkes, 1996; Arkes & Blumer, 1985). Progress decisions involve the choice of whether to continue pouring investments toward an ongoing course of action. In a common procedure subjects read a hypothetical scenario in which they have spent a certain amount of money towards a project that now appears to have bleak chances for success, and they must decide whether to continue funding the project (e.g., Arkes & Blumer, 1985; Garland, 1990; Garland & Newport, 1991). The basic finding in these studies is that the likelihood of persistence increases as sunk cost — i.e., the money spent so far — increases.

To date, the majority of the research on the sunk cost effect has involved college students and questionnaire-type procedures, and most interpretations of the sunk cost effect have come from cognitive and social psychology frameworks. The most widely-discussed theories that have been used to account for this phenomenon are self-justification (Staw, 1976), prospect theory (Whyte, 1986), and a desire to avoid waste (Arkes & Blumer, 1985). Despite the social and cognitive slant of most conceptions of the sunk cost effect, research from several laboratories, including our own, has been exploring the sunk cost effect using a behavior-analytic framework. This research has provided important contributions to our understanding of the effect, in large part by highlighting the importance of some previously-ignored variables. For example, research by Goltz (1992, 1993, 1999) and by Bragger and her associates (Bragger, Bragger, Hantula, & Kirnan, 1998; Bragger, Bragger, Hantula,

Kirnan, & Kutcher, 2003) has suggested that reinforcement history plays a role in determining how long we persist in a losing financial endeavor. In particular, subjects with a prior history of intermittent reinforcement will throw more (hypothetical) money at a losing venture, e.g. a fading stock, than subjects with a prior history of continuous reinforcement. Goltz has suggested that the partial reinforcement extinction effect and behavioral momentum may often lie at the root of such persistence. Thus, the sunk cost effect may not necessarily be an “irrational” behavior—rather, we may persist in a fruitless endeavor because we have not learned that persistence is non-optimal.

Recent work from our laboratory has highlighted this general point in a different manner. First of all, we have developed a more stripped-down behavior-analytic analog of the effect. One of our goals was to have an analog of this maladaptive behavior that would allow us to explore the effect in non-humans as well as humans, in hopes of determining the degree to which this behavior is general across species. A second goal was to have a procedure that would allow us to explore the sunk effect in more general terms in order to evaluate stimulus-response relationships present in sunk cost situations.

Our first study used the analog with pigeons and humans (Navarro & Fantino, 2005), and suggested that persistence in a losing venture may occur when an organism is unable to discriminate when the venture is losing. Pigeons were placed individually in an operant chamber in which they could peck either of two keys: a “reward” key colored white, or an “escape” key displaying a white “X”. College students were presented with an analogous task on a computer console. For a large number of trials, the subjects had to peck (or press) the reward key an undetermined number of times until they received a reward. At any time they could respond on the escape key to cancel the current trial and initiate a new one. A new trial began either after one response to the escape key or after a reward (food for the pigeon, money for the college student). The reward key modeled a course of action that started off with favorable prospects but turned unfavorable: it offered a diminishing chance of reward as responses incremented. In other words, as subjects responded without getting a reward, the amount of work remaining for reward became increasingly large. For example, in one condition the “reward” key operated on one of four fixed-ratio (FR) schedules: on 1/2 the trials, the schedule was FR 10; on 1/4 of the trials, the schedule was FR 40; on 1/8 of the trials, the schedule was FR 80; and on 1/8 of the trials, the schedule was FR 160. The expected ratio remaining to reward therefore increased through a trial in the following manner: at the start of a trial the expected ratio was 45. After the 10th response, if no reinforcement occurred (because the schedule in effect happened to be one of the three longer ratios) the expected ratio increased to 70. After the 40th response, if no reinforcement occurred, the expected ratio increased to 80. After the 80th response, if no reinforcement occurred,

the expected ratio remained at 80. A subject's optimal strategy was to escape after 10 responses to the reward key, thereby lowering the expected ratio from 70 to 45. Notice that this procedure corresponds to a "progress decision"—subjects undertake a course of action and subsequently may either continue pouring investments into that course of action or instead move on to a new one.

In that study, we manipulated two variables that we expected could affect the level of persistence. One was the arithmetic difference between the expected ratio of escaping after responding the number of times required by the shortest FR (in the above example, 10 times) and persisting past that point. In the condition described above, this difference is 24 { $24 = 70 - (45 + 1$ response to the escape key)}. By changing the FR values and probabilities, we created a second condition in which the difference was 44, and a third condition in which the difference was only 19. Both pigeon and human subjects showed the following trend: when the difference between the expected ratio of escaping and persisting was small, subjects tended to persist; when the difference was large, subjects tended to escape, i.e., behave optimally. As the contingencies were made more difficult to discriminate, persistence tended to increase.

We performed a second manipulation that also examined this point, but only with pigeon subjects. We manipulated whether or not discriminative stimuli were present that were correlated with the expected ratio remaining to reward. In one condition the stimulus on the reward key never changed throughout a trial. In the other condition, the stimulus on the reward key changed with each increment of the expected ratio. At the start of a trial, the reward key was white; after the 10th response, the key turned red; after the 40th response, the key turned blue; and after the 80th response, the key turned green. The data are shown here in Table 1. As expected, when these discriminative stimuli were present, pigeons selected optimally. When the key light changed after 10 non-rewarded responses, the pigeons immediately selected the escape key, initiating a new trial. When these discriminative stimuli were absent, however, only one of four pigeons selected optimally. The remaining three pigeons consistently persisted in responding on the food key until food was ultimately (and arduously) obtained. These results, like those from the experiment manipulating the expected ratios, indicate that a determinant of persistence is an organism's ability to discriminate when conditions have deteriorated.

In the present study, we set out to expand upon those findings by repeating the latter experiment—the one manipulating the presence or absence of discriminative stimuli—with human subjects. To what extent would the behavior of human subjects be affected by this manipulation? We employed the same basic procedure we used with the pigeons, but with pressing a computer key as the operant and money as the reinforcer.

	<i>Session of stable period</i>	<i>Bird 361</i>	<i>Bird 362</i>	<i>Bird 363</i>	<i>Bird 364</i>
Stimulus changes present**	Session 1	0%	0%	0%	0%
	Session 2	0%	0%	0%	0%
	Session 3	0%	0%	0%	0%
	Session 4	0%	0%	0%	0%
	Session 5	0%	0%	0%	0%
Stimulus changes absent	Session 1	3%	100%	97%	100%
	Session 2	4%	100%	100%	100%
	Session 3	1%	100%	100%	100%
	Session 4	1%	100%	100%	100%
	Session 5	2%	100%	100%	100%

*Table 1. From Navarro & Fantino (2005), Experiment 1: Percentage of Trials With Persistence**

**Persistence in a trial is defined as completion of that trial (excluding FR 10 trials)*

***The data for the first 5-8 sessions of this condition were lost because of a computer malfunction. The data shown here are from the first 5 sessions for which data are available. For this reason it is unknown for each pigeon whether "Session 1" is truly the first session of the stable period or is instead subsequent to the first session of the stable period*

METHOD

Subjects. 68 undergraduate men and women participated in this study for course credit.

Apparatus. Four IBM-compatible computers programmed in Turbo Pascal. The four computers were located in a small room and were separated by partitions.

Procedure. Subjects faced a computer task in which they had to respond on a keyboard in order to earn imaginary money. The instructions indicated the following: 1) the session would last 30 minutes; 2) the main task was to earn as much money as possible, and the money was hypothetical; 3) during a trial, subjects could either press "L", followed by ENTER, an undetermined number of times until the screen flashed a \$1 reward, or press "K", followed by ENTER, to cancel that trial and initiate a new one. Subjects moved from the instruction screen to the actual procedure by pressing ENTER.

As subjects responded during a trial, the key instructions appeared on the top left of the screen; the words "no money yet..." appeared at the center of the screen, and the total earnings for the session appeared at the bottom right of the screen. On every trial, one of four fixed-ratio (FR) schedules was in effect on the reward key. On 1/2 the trials, the schedule was FR 10; on 1/4

of the trials, the schedule was FR 40; on 1/8 of the trials, the schedule was FR 80; and on 1/8 of the trials, the schedule was FR 160. A random number generator determined the ordering of trials within successive eight-trial blocks, meaning that in every block of eight trials the FR 10 occurred four times, the FR 40 occurred two times, and the FR 80 and FR 160 each occurred once. Each trial lasted until the reinforcement schedule was completed or until the trial was canceled.

Upon completion of an FR schedule, the screen went blank and the sentence “you won \$1!” appeared at the center of the screen for 2 s. Then, the sentence “new trial begins in a moment” appeared at the center of the screen for 2 s, after which the main screen reappeared with the total earnings incremented appropriately. If a subject canceled a trial, the screen went blank and the sentence “new trial begins in a moment” appeared at the center of the screen for 2 s, followed by the main screen.

Subjects were randomly assigned to one of two conditions: either stimulus-changes-absent or stimulus-changes-present. In the changes-absent condition, all characters presented on the monitor were white in color over a black background. In the changes-present condition, at the start of a trial the characters were white and the word “white” appeared at the bottom of the screen. After the 10th reward-key response, if no reinforcement occurred, all characters became red and the word “red” appeared at the bottom of the screen. After the 40th reward-key response, if no reinforcement occurred, all characters became blue and the word “blue” appeared at the bottom of the screen. After the 80th reward-key response, if no reinforcement occurred, all characters became green and the word “green” appeared at the bottom of the screen. Screens that designated reinforcement or the delay to the next trial always displayed white characters.

One to four subjects performed the experiment simultaneously depending on how many subjects had happened to sign up for a given time slot. Subjects were asked to complete two 30-minute sessions. Subjects could schedule the two sessions back-to-back or up to one week apart. The number of trials per session differed between subjects but was typically between 50 and 100 trials.

RESULTS

Forty-one subjects participated in the changes-absent condition, and 37 subjects participated in the changes-present condition. Only 39 and 29 subjects, respectively, completed two sessions of each condition. The focus of the data analysis was on second-session behavior. We defined persistence as completion of one of the three longer ratios, i.e. FR 40, FR 80, and FR 160 (we did not count completion of an FR 10 as persistence since completion of that ratio

is optimal). Table 2 shows the percentage of trials (in which persistence was possible) that were completed, ordered in each condition from the subject with the lowest persistence to the subject with the highest persistence. In the changes-absent condition, the average percentage of trials with persistence was 56.9% (SD = 45.97). In the changes-present condition, the average percentage was 34.8% (SD = 42.50). A one-way ANOVA revealed a significant effect of condition on the percentage of trials with persistence, $F(1, 66) = 4.09, p < .05$.

Condition	Individual data, ordered from subject with lowest second session datum to subject with highest second session datum	Mean	SD
Stimulus-changes-absent	0, 0, 0, 0, 0, 0, 0, 1, 1, 2, 3, 4, 5, 7, 16, 36, 45, 56, 70, 90, 94, 96, 97, 97, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100	56.9	45.97
Stimulus-changes-present	0, 0, 0, 0, 0, 1, 1, 1, 2, 2, 2, 3, 4, 4, 6, 9, 19, 28, 41, 48, 49, 94, 96, 100, 100, 100, 100, 100, 100	34.8	42.50

*Table 2. Percentage of Trials with Persistence, Second Session**
**Persistence in a trial is defined as completion of any but an FR 10 trial.*

Behavior was more optimal in the second session than in the first session. In the changes-absent condition, the level of persistence in the first session was 67.7% (SD = 39.72). In the changes-present condition, the level of persistence was 45.7% (SD = 41.03). Thus, from the first to the second session the level of persistence in both conditions decreased by about 10 percentage points.

In both conditions, the second-session data show a bimodal pattern in which the majority of subjects either persisted regularly or escaped regularly, as shown in Figure 1. We may label the subjects who persisted in at least 90% of the trials as “persisters”, and the subjects who persisted in under 10% of the trials as “escapers”. In the changes-absent condition, 50% of the subjects were persisters while 35% were escapers. In the changes-present condition, the number of persisters decreased to 27.5% while the number of escapers increased to 56%.

A significant proportion of the subjects never responded on the escape key during either session. In the changes-absent condition, this was 14 out of 39 subjects; in the changes-present condition, this was 2 out of 29 subjects. We address this issue in the discussion.

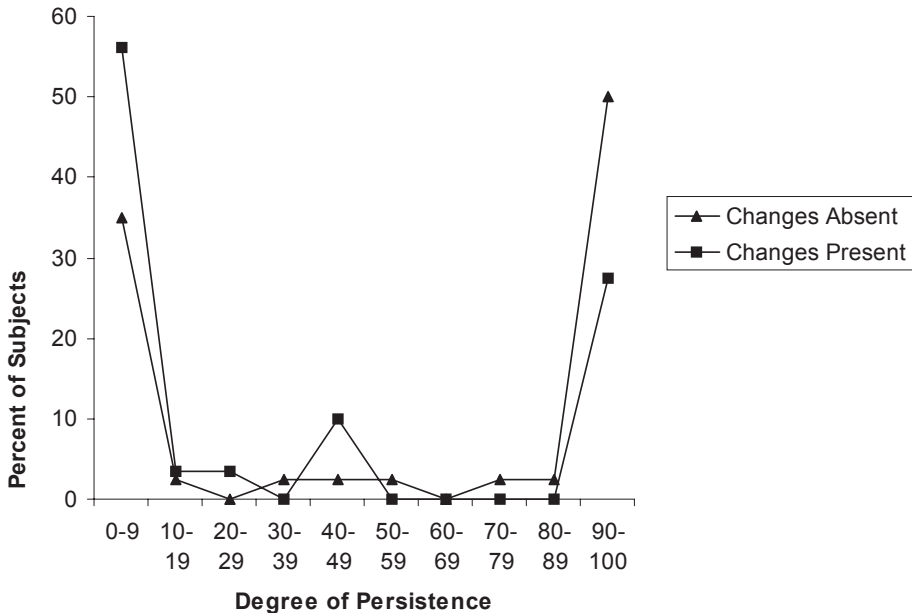


Figure 1. Histogram of the degrees of persistence.

DISCUSSION

In the present research we explored the effect of discriminative stimuli on persistence in a non-optimal course of action. We employed a procedure we had developed in our previous research in which subjects had to respond a certain number of times to obtain a reward, but as responses mounted the average number of responses left to reward increased. The optimal behavior was to “escape” (i.e., move on to the next trial) after the minimum possible response requirement had been met without reward. In a prior study with pigeon subjects, we manipulated the presence or absence of discriminative stimuli correlated with the expected ratio left to reward (Navarro & Fantino, 2005). We found that all pigeons behaved optimally when discriminative stimuli were present, but when discriminative stimuli were absent most of the pigeons persisted to the end of every trial. The present experiment repeated this manipulation with human subjects. The results are similar to our prior finding with pigeon subjects—the presence of discriminative stimuli led to more optimal behavior.

We note that the behavior of the human subjects in the present experiment was quite variable, as evidenced by the high standard deviation in each condition and by the variety in the individual data shown in Table 2. A potential reason for this variety is that two sessions were not enough to allow behavior to become stable for all subjects. Indeed, in our prior study with pigeon subjects, the pigeons underwent far more sessions before their data were stable and therefore analyzed. Another potential reason for the variability in these data is our use of imaginary money as the reinforcer. It is plausible that some subjects were sufficiently motivated by this reinforcer while others were not. Despite these two procedural issues, our results indicate that, at least initially, human subjects are more likely to persist in a non-optimal course of action if no discriminative stimuli are available to signal changes in the contingency.

One issue of potential concern is the result that many subjects—nearly one quarter of them, but mostly in the changes-absent condition—never once contacted the escape key. One could argue that since these subjects never directly contacted the escape contingency, it would not be meaningful to label their persistence as non-optimal. The counter-argument is that the instructions discussed the function of the escape key, and during the trials the screen always displayed, “press K, followed by ENTER, to reset the trial”. It seems unlikely that the extreme persisters were unaware of the escape key function. Therefore, we believe it is meaningful to label their persistence as non-optimal.

The present research taken together with our prior research suggests the following cause of persistence in a non-optimal endeavor: the failure to discriminate when the endeavor has become non-optimal. If the contingencies of reinforcement are salient, then both pigeons and humans will behave in a manner that maximizes profit. On the other hand if the contingencies are not salient, then pigeons and humans will tend to persist in whatever course of action they are engaged in. In essence, pigeons and humans tend to stick with a particular course of action until they can discriminate the fact that other options are more profitable.

We should mention that the present experiment also represents a novel way of studying choice under diminishing returns. Others have studied this type of choice behavior by programming a concurrent progressive ratio (or interval) — fixed ratio (or interval) schedule, whereby completion of the fixed ratio results in a resetting of the progressive ratio (Hackenberg & Himeline, 1992; Hodos & Trumbule, 1967). The progressive ratio key is analogous to our reward key since the value diminishes over time, and the fixed ratio key is analogous to our escape key. However, there is a crucial difference between the two procedures: in a progressive schedule, the ratio (or interval) increases after every reinforcement, whereas in our procedure the schedule—from a subject’s perspective—increased during a trial and was reset after reinforce-

ment. The two procedures are not truly comparable, which precludes us from discussing our results in terms of previous findings in this area.

Finally, our research and that of others (Goltz, 1992, 1993, 1999; Bragger et al., 1998; Bragger et al., 2003) suggest that behavior analysis may be a useful method of exploring the sunk cost effect. This research has identified several variables important to the effect, most notably reinforcement history and discriminative stimuli. We are confident that continued use of the behavior-analytic method may lead to the discovery of additional variables relevant to this maladaptive behavior and a more complete understanding of why we sometimes “throw good money after bad”.

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