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STIMULI EFFECTS ON OPTIMAL BEHAVIOR IN A SUNK-COST SITUATION WITH PIGEONS

EFECTOS DEL ESTÍMULO SOBRE LA CONDUCTA ÓPTIMA EN UNA SITUACIÓN DE COSTO DE LA INVERSIÓN CON PALOMAS

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Abstract

The contribution of varying the response requirement frequency on the occurrence of escape-optimal and persistence-optimal behavior versus impulsive behavior was evaluated in food-deprived pigeons. According to an ABACA design, the subjects were exposed to the following arrangements of fixed ration (FR) response requirements and probabilities of presentation of each one: for the A conditions the arrangements were FR 10 p=0.50, FR 40 p=0.25, FR 80 p=0.125 or FR 160 p=0.125. For the B condition the arrangements were FR 10 p=0.125, FR 40 p=0.50, FR 80 p=0.25 or FR 160 p=0.125. For the C condition the set was FR 10 p=0.0625, FR 40 p=0.0625, FR 80 p=0.50 and FR 160 p=0.375. These FR response requirements with their respective probabilities were evaluated under two phases of the experiment, a signaled and an unsignaled one. Globally, it was found that the relative frequency of the FR response requirements controlled the occurrence of escape and persistence optimal behavior or impulsive behavior. These effects of the response frequency were modulated by the presence versus absence of a stimulus signaling the response requirement changes. These findings were interpreted as congruent with those previously reported in similar procedures.

Key words: *sunk-cost effect, stimulus effects, optimal behavior, pigeons.*

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Resumen

Se averiguó la contribución de variar la frecuencia relativa de los requisitos de respuesta sobre la ocurrencia de la conducta de escape o de persistencia optimas versus la conducta impulsiva. Conforme a un diseño ABACA se expuso a cuatro palomas privadas de comida a los siguientes arreglos de requisitos de respuestas por reforzador (RF) y sus correspondientes probabilidades de presentación: Para las condiciones A los arreglos fueron RF 10 p=0.50, RF 40 p=0.25, RF 80 p=0.125 or RF 160 p=0.125. En el caso de la condición B los arreglos fueron RF 10 p=0.125, RF 40 p=0.50, RF 80 p=0.25 or RF 160 p=0.125. Para la condición C los arreglos fueron RF 10 p=0.0625, RF 40 p=0.0625, RF 80 p=0.50 and RF 160 p=0.375. Se evaluaron los efectos de variar la frecuencias de los requisitos de respuesta en presencia y ausencia de cambios de estímulo que señalaron los cambios entre los requisitos. Globalmente, se encontró que la frecuencia relativa de presentación de los requisitos de respuesta controló la ocurrencia de la conducta de escape o persistencia optima y de la conducta impulsiva. Aún más, se encontró que los efectos de variar la frecuencia de los requisitos de respuesta estuvieron modulados por la presencia o ausencia del estímulo que señaló la presentación de los mismos. Se interpretaron estos hallazgos como congruentes con los reportados previamente en procedimientos similares.

Palabras clave: *efecto del costo de la inversión, efectos del estímulo, conducta óptima, palomas.*

The interest of this paper is on a phenomenon called the sunk-cost effect that was originally reported with humans who persist in or abandon different tasks that involve further investments of time, effort or money despite the loses of previous investments. In most of the previous studies it was suggested that the sunk-cost effect occurred only with humans and it depended of variables like reinforcement history and the uncertainty involved in the task (cf. Arkes & Ayton, 1999 for a review of the corresponding literature). However, some theorists suggested that the sunk-cost effect could also occur with non-human organisms (e.g., Goltz, 1993, 1999; Navarro & Fantino, 2005, 2007).

For instance, after a review of the literature, Navarro and Fantino suggested that, given that uncertainty contributes to the tendency of humans to show the sunk-cost effect, this variable could also produce the effect in non-humans subjects.

Therefore, to find out if the sunk-cost effect occurs in pigeons, they designed an operant procedure that can be described globally as follows: in a trial by trial situation a food reinforcer is programmed according to different response requirements (key pecks) and each one can be presented with a given probability. The combination of the response-requirement magnitudes and their respective probabilities defined the condition as an escape optimal or a persistence optimal one.

Both conditions are optimal in the sense that in either one the subject can obtained most of the reinforces programmed. Given the previous conditions, the subject can persist in the trial by pecking a food key until the reinforcer is delivered or it can escape from the trial by pecking a different key (escape key).

Thus, the subject is exposed to the following situations: under escape-optimal conditions if the subject escapes then it is sensitive to the reinforcement contingencies but, if the subject persists it shows a sunk-cost effect. By contrast, under persistence-optimal conditions if the subject escapes then it shows impulsive behavior but, if the subject persists then it is sensitive to the reinforcements contingencies.

By using the general procedure previously described, Navarro and Fantino, in their Experiment 1, examined the role of uncertainty in the sunk-cost effect by comparing persistence in an operant situation under stimulus present versus stimulus absence conditions under the hypothesis that the stimulus can modulated the uncertainty involved in the situation.

Specifically, they exposed four food-deprived pigeons to a trial by trial procedure in which pecking the center key of an experimental chamber resulted in 3 s of access to food as reinforcer according to one of four different fixed ratio (FR) response requirements. At the beginning of each trial one of the four FR schedules was available with a predetermined probability. A single peck on the left key, from hereinafter the escape key, cancelled the current trial and started a new one in which the response requirement could be lower than the previously cancelled. The response requirements scheduled and their corresponding probabilities were: FR 10 p=0.50, FR 40 p=0.25, FR 80 p=0.125 or FR 160 p=0.125. In the first experimental condition the different FR response requirements were signaled with a different color of the center key.

For instance, if in a given trial the reinforcer was available according to a FR 160 then at the beginning of it the center key was lit in white (signaling FR 10), after 10 responses the key-light color changed from white to red (signaling FR 40).

After 30 more responses the key-light color changed to blue (signal for FR 80) and after 40 more responses the key-light changed to green (FR 160).

Given this example with a FR 160, each color remained on until each response requirement without reinforcement was reached or an escape response occurred. In the second condition the center key was always lit in white, regardless of the response requirement changes. For both conditions the escape key, was illuminated with a white X. According to the previous description of the phenomenon, the number of response requirements longer than the shortest one that were completed per session was the main dependent variable which was expressed as percentage of trials with persistence. In both conditions, given the arrangements of FR schedules and their probabilities, the optimal behavior was to escape after the shortest FR response requirement was completed without reinforcement. Thus, to persist instead of showing optimal behavior was an example of a sunk-cost effect. Navarro and Fantino found that, in the first condition in which the stimulus change was associated with the different response requirements the percentage of trials with persistence was zero in almost all the sessions. In the second condition, in which there was no stimulus change signaling the different FR response requirements, the percentage of trials with persistence was 100% in almost all the trials. Navarro and Fantino concluded that the stimulus changes effectively turn the escape optimal situation more salient and therefore, facilitated the optimal escape behavior. By contrast, the absence of the stimulus resulted in persistence under an escape-optimal situation and thus in a sunk-cost effect.

The authors suggested that in the stimulus present condition of the previous experiment the results could be due to the impulsive behavior controlled by short delays to food instead of the uncertainty implied in the situation. This impulsivity could be observed in the fact that the subjects completed mainly the shortest FR response requirement and escaped from the higher FR schedules. To address this question in their Experiment 2, Navarro and Fantino exposed four food-deprived pigeons to an escape-optimal condition and then to a persistence-optimal condition. Briefly, the escape-optimal condition was the same as the stimulus-change condition from Experiment 1 and in the persistence-optimal condition the set of response requirements was as follows: FR 10 p=0.25, FR 30 p=0.58 or FR 50 p=0.17.

In this second condition there was also a stimulus change signaling the different FR response requirements. The authors found that, as in their Experiment 1, in the escape-optimal condition the percentage of trials with persistence was almost 0%, and in the persistence-optimal condition the dependent variable was 100% for most of the sessions.

With the results of the previous two experiments, the authors demonstrated that when a stimulus signals the response requirement changes the subjects show optimal behavior which means to escape or persist when the response requirement and probability sets establish escape or persistence optimal conditions.

In the discussion section of their Experiment 2, the authors noted that the FR 10 response requirement had a 0.50 or a 0.25 probability of presentation in the escape-optimal or the persistence-optimal condition, respectively. These probabilities could produce different frequencies of FR 10 presentations and thus, instead of optimal behavior, the persistence-optimal condition could generate less opportunities for impulsive behavior to occur. As Navarro and Fantino mentioned, this possibility precludes any explanation of their results exclusively in terms of optimization; that is, in the persistence-optimal condition the subjects could persist no because they we sensitive to the contingencies but because there were few opportunities to respond for a less delayed reinforcer.

The authors of this paper do not known any reference in the choice literature regarding the contribution of varying the frequency of presentation of short-immediate versus long-delayed reinforcers on the choice between them. However, it is possible that the relative frequency of the options could modulate the occurrence of impulsive or self-controlled behavior. Therefore, the purpose of the present study was to analyze even more the contribution of the relative frequency of the response requirements on the optimal or impulsive behavior occurrence in the sunk-cost situation described by Navarro and Fantino.

As explained before, the authors compared a 0.5 with a 0.25 probability of presentation of the FR 10 response requirement and, according to the previous purpose, in the present study the effects of a 0.5 probability of presentation of the FR 10 were compared with those of a 0.125 and a 0.0625 probability of the response requirement. To further extend the comparison between the effects of the response-requirement frequencies on the optimal versus impulsive behavior, in this study these effects were determined under optimal escape or persistence conditions in which a stimulus change signaled or not signaled the response-requirement changes.

Method

Subjects

Four pigeons served as subjects. They had previous experience with different schedules of food reinforcement and were kept at 80% of their free-feeding weight, in individual home cages and with free access to water and grit.

Apparatus

Three modular pigeon chambers were used (MED Assoc. Mod. ENV-007). Each one was equipped with three response keys located on one wall, and behind each one a light projector was mounted (MED Assoc. Mod. ENV-123 AM); below the keys a food dispenser was attached and used to deliver grain as reinforcer (MED Assoc. Mod. ENV-205 M).

On the opposite wall a house light (MED Assoc. Mod. ENV-215 M) was located. Only the left and the center keys were used to present stimuli and to record key pecks. The left key was illuminated with a yellow light and the center key could be illuminated with white, red, blue, or green light. Each chamber was put inside a sound-proof box (MED Assoc. Mod. ENV-018 MD).

A minimum force of approximately 0.15 N was required to operate each key. During reinforcement delivery, the house light and all key lights turned off and a magazine light turned on. The chambers were connected to a personal computer through an interface (Med Assoc. Mod. DIG-716 P2); both were located in an adjacent room. MED PC-IV programming language (MED-SYST-8) was used to present the experimental events and to record key pecks.

Procedure

In a preliminary training condition, each pigeon was shaped by successive approaches to peck the center key while it was illuminated with white. After shaping, the response requirement was increased gradually from FR 1 to FR 60, while the center key remained illuminated with white. Afterwards, the key was illuminated with red and the pigeons were trained on the same response requirements as those used in the previous condition. The same procedure was followed to train the pigeons on blue and green stimuli. After training they were exposed to the procedure that will be described below.

At the beginning of each trial one of four FR schedules was in effect on the center key according to a predetermined probability. Completion of a FR schedule resulted in 3 s of access to grain followed by a new trial. The FR response requirement set was composed of FR 10, FR 40, FR 80 and FR 160 responses per reinforcer. Each of these FR response requirement occurred with a specific probability in each of five experimental conditions according to an ABACA design.

In the A conditions the set of response requirements and probabilities was FR 10 p=0.50, FR 40 p=0.25, FR 80 p=0.125 and FR 160 p=0.125. In the B condition the set was FR 10 p=0.125, FR 40 p=0.50, FR 80 p=0.25 and FR 160 p=0.125. and in the C condition the set was FR 10 p=0.0625, FR 40 p=0.0625, FR 80 p=0.50 and FR 160 p=0.375.

For all conditions, the changes between response requirements were signaled by changes in the center-key color. For instance, in a given trial a FR 160 was selected and, at the beginning of it the center key was illuminated with white; after 10 responses (FR 10) the key color changed to red, after 30 more key pecks (FR 40) the key color changed to blue and, after other 40 responses (FR 80) the key color changed to green.

Finally, while the key remained lightened with green and after 80 more responses (FR 160), the reinforcer was delivered. Throughout each trial, the left yellow key was operative and a response on it produced a 1-s blackout followed by a new trial and, the center key was again illuminated with white. However, the subjects were not explicitly trained to peck the left yellow key.

In a second phase of the experiment, the same three combinations of the FR response requirements with their probabilities were tested but, in contrast with the first phase, without any stimulus change signaling the different FR schedules; the central key remained illuminated with a white light throughout each trial.

For both phases of the experiment, each session terminated after 80 reinforcers were delivered. The number of sessions of exposure to each condition was the same for the four pigeons but varied between conditions. Specifically, the subjects were exposed during 20, 20, 20, 30, and 20 sessions with the stimulus change present to the ABACA conditions and during 40, 20, 30, 20, and 30 to the same conditions of the experiment but without a stimulus change added to the procedure.

Results

The dependent variable was the percentage of trials with persistence which was defined as the number of trials in which a FR 40, 80 or 160 was in effect and resulted in reinforcement.

Figure 1 shows the percentage of trials with persistence per session for each pigeon (rows) that was exposed to the consecutive combinations of FR response requirements and their probabilities of presentation for the conditions in which a different stimulus signaled each FR response requirement (columns ABACA).

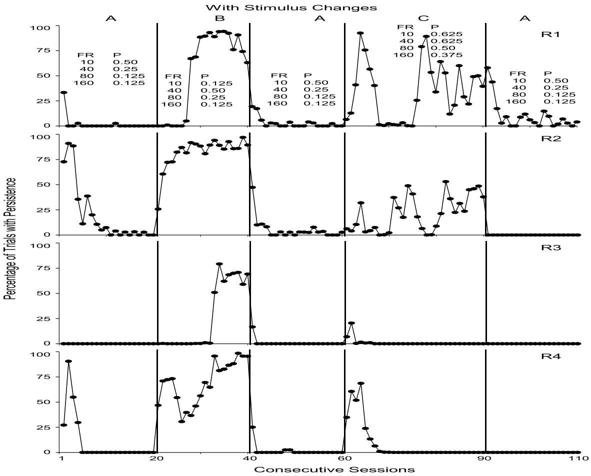

Figure 1. Percentage of trials with persistence for each subject (rows) during the consecutive sessions of exposure to the different experimental conditions (columns ABACA) with stimulus changes signaling the changes between response requirements. The specific arrangements of response requirements and their probabilities are indicated within each panel in the top row.

In the first experimental condition (A condition), when the combinations between FR response requirements and probabilities were FR 10 *p*=0.50, FR 40 *p*=0.25, FR 80 *p*=0.125, and FR 160 *p*=0.125, respectively, for pigeons R1, R2 and R4 the percentage of trials with persistence varied between 25 and 100% approximately in the first sessions and, thereafter, the dependent variable decreased as the sessions of exposure to the condition elapsed. For pigeon R3 the percentage of trials with persistence remained in 0% throughout the condition.

When the combinations between FR response requirements and probabilities were FR 10 *p*=0.125, FR 40 *p*=0.50, FR 80 *p*=0.25, and FR 160 *p*=0.125, (B condition) the percentage of trials with persistence increased from 0% to a range between 40 and 100% approximately for the four pigeons, but after a different number of sessions of exposure to the condition.

Exposing the pigeons again to the A condition resulted in an abrupt decrease of the percentage of trials with persistence to near 0% for the four subjects in comparison with the level observed in the previous condition.

For the next experimental condition when the combinations between FR response requirements and probabilities were FR 10 *p*=0.0625, FR 40 *p*=0.0625, FR 80 *p*=0.50, and FR 160 *p*=0.375 (C condition) for pigeons R1 and R2 the percentage of trials with persistence varied between 5 and 100% approximately as the sessions elapsed. For pigeons R3 and R4 the percentage of trials with persistence remained in 0% during most of the sessions of exposure to the condition.

In the last exposure to the A condition the percentage of trials with persistence was 0% for subjects R2, R3 and R4 and varied between 60% and 0% for pigeon R1, as in the two previous exposures to this condition.

Figure 2 shows the dependent variable for each pigeon (rows) that was exposed to the consecutive combinations of FR response requirements and their probabilities of presentation when the changes between FR response requirements were not signaled (columns ABACA).

For pigeon R1 the percentage of trials with persistence remained in 100% during almost all the sessions of exposure to the experimental conditions, regardless of the changes in the set of response requirements and probabilities.

For the other three pigeons, when the set of response requirements and probabilities was FR 10 *p*=0.50, FR 40 *p*=0.25, FR 80 *p*=0.125, and FR 160 *p*=0.125 (first A condition) the percentage of trials with persistence varied between 100% in the first few sessions and 0% in the rest of the sessions.

The dependent variable increased to a range between 60 and 100% when the response requirement and probability set was FR 10 *p*=0.125, FR 40 *p*=0.50, FR 80 *p*=0.25, and FR 160 *p*=0.125 (B condition).

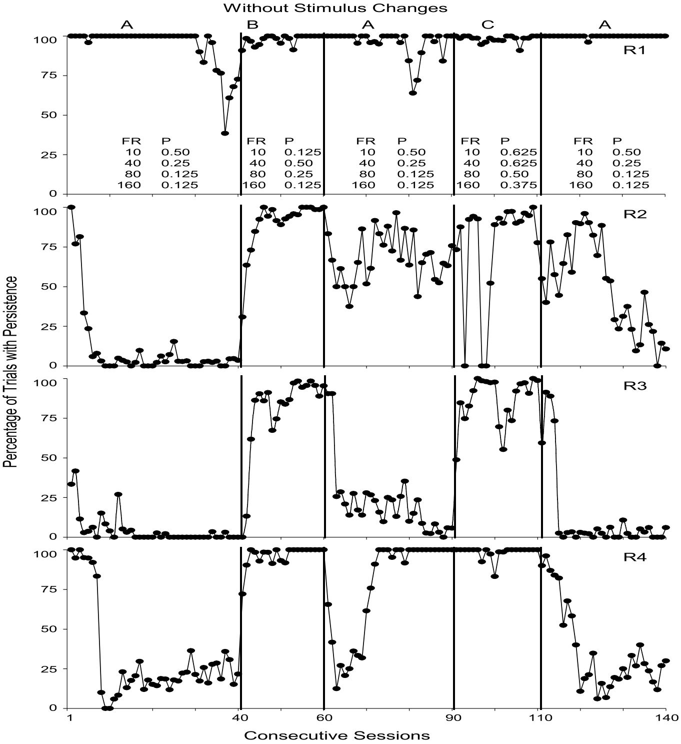

Figure 2. Percentage of trials with persistence for each subject (rows) during the consecutive sessions of exposure to the different experimental conditions (columns ABACA) without stimulus changes between response-requirement changes. The set of response requirements and their probabilities are indicated within each panel in the top row.

During the second exposure to the A condition the percentage of trials with persistence varied between 50 and 100% for R2 and R4 and varied between 0 and 30% for R3 in most of the sessions.

Exposing the three pigeons to the response requirement and probability set of FR 10 $p=0.0625$, FR 40 $p=0.0625$, FR 80 $p=0.50$, and FR 160 $p=0.375$ (C condition) resulted in a percentage of trials with persistence that varied between 50 and 100% in almost all sessions. In the last exposure to the A condition the percentage of trials with persistence decreased from 100% to levels that varied between 50 and 0% for the three pigeons.

Discussion

The present experiment can be conceptualized as a systematic replication of the procedure and findings reported by Navarro and Fantino (2005) in their

Experiment 2. Therefore, for the sake of clarity, their Experiment 2 will be described first and thereafter the corresponding comparisons with the present experiment will be presented and discussed.

In their Experiment 2, Navarro and Fantino exposed four pigeons to an escape-optimal condition for which the response-requirement magnitudes and their probabilities were FR 10 p=0.50, FR 40 p=0.25, FR 80 p=0.125, and FR 160 p=0.125 and the changes between the response requirements were signaled with a key-color change. Thereafter, the authors exposed the same pigeons to a persistence-optimal condition in which the FR response requirements and probabilities were FR 10 p=0.25, FR 30 p=0.58, and FR 50 p=0.17. This second condition also had a key-color change signaling the different schedules of reinforcement.

They found that the four pigeons behaved optimally in both conditions; that is, the subjects escaped from or persisted in the task as required by the arrangements of FR schedules and probabilities.

In the first phase of the present experiment in which the FR response-requirements were signaled by a different key color, the first and second conditions were a systematic replication of the escape and persistence-optimal conditions reported by Navarro and Fantino and, as they found, the subjects persisted 0% of the trials in the first condition and almost 100% of the trials in the second one. These results suggest an explanation congruent with that of Navarro and Fantino, that is, the subjects behaved optimally; they escaped or persisted in the corresponding condition, instead of just behave impulsively regardless of the contingencies.

In the present study, the third condition was a replication of the first exposure to the escape-optimal condition and the same percentage of trials with persistence was observed. The fourth condition was an extension of the persistence-optimal condition by making the FR 80 response requirement the most probable. It was found that although the condition was defined as one of optimal persistence the subjects did not persist consistently. The last condition was a replication of the procedure and results of the first two exposures to the escape-optimal condition.

The results observed in the three A conditions of the experiment show the recoverability of optimal-escape behavior in this kind of procedures. The results of the B and C conditions, in turn, show that the performance of the subjects under persistence-optimal conditions depends on the specific arrangements of the FR response requirements and probabilities. That is, if a persistence-optimal condition requires a relatively short number of responses per reinforcer the subject will persist consistently. By contrast, if the persistence- optimal condition specifies a relatively long number of responses per reinforcer then the subjects will not persist consistently or will escape even though persistence is the optimal behavior. As Navarro and Fantino anticipated, these last results support an impulsivity explanation of the behavior observed under the persistence-optimal condition; that is, in the C condition the relatively high response requirement involved a larger delay to the reinforcer than in the previous B condition. Therefore, a interesting conclusion from these results is that to persist or to behave impulsively in a persistence-optimal condition depends of the response magnitude specified by the response requirements; these response magnitudes, in turn, involved different durations of the delay to the reinforcer. This conclusion seems reasonable considering that, as has been reported in the literature on self-controlled behavior, the choice between a short and a larger reinforcer depends on the relative duration of the delays involved in the two options of the choice (e.g., Rachlin & Green, 1972; van Haaren, van Hest, & van de Poll, 1988).

The procedure previously described could be conceptualized as one in which the uncertainty of the task was relatively low because a stimulus signaled the changes between FR response requirements; the escape or persistence optimal conditions could be clearly discriminated. By contrast, in the second phase of the present study, the effects of escape-optimal and persistence-optimal conditions on the percentage of trials with persistence was evaluated under unsignaled presentations of the FR response requirements. Therefore, this second procedure could be considered as one in which the uncertainty of the outcome of the task was relatively high. In general, it was found that there was too much variability within and between subjects in the percentage of trials with persistence for the three escape-optimal conditions (A conditions). For the two persistence-optimal conditions (B and C conditions) the dependent variable remained in almost 100% for all subjects and in most of the sessions of exposure to these conditions.

These results are intriguing because, like a figure-frame perceptual problem, they seem to be contradictory and at the same time congruent with those reported by Navarro and Fantino in part of their Experiment 2 previously described and in their Experiment 1 which will be briefly described before explaining the corresponding comparisons. The authors exposed pigeons to a trial-by-trial procedure in which they could earn food as reinforcer according to a FR 10, 40, 80 or 160 responses that were available with a probability of 0.50, 0.25, 0.125 and 0.125, respectively. In a first experimental condition a key-color change signaled the presence of each FR response requirement and in a second condition the response requirements were presented without any stimulus. They found that when a stimulus signaled the different FR response requirements the four subjects persisted 0% of the trials and when the stimulus was absent three of the four subjects persisted 100% of the trials.

In the present experiment, the first A condition of this second experimental phase was supposed to result in a high percentage of trials with persistence because, as Navarro and Fantino suggested in their Experiment 1, given the lack of a stimulus signaling the response requirement changes, the uncertainty involved in the task was relatively high and this should have resulted in a high persistence. However, only one of four pigeons behaved as predicted, and the other three pigeons escaped consistently in most of the sessions of exposure to this condition. The simplest explanation of this first contradictory result is that given the within-subject design used in the present study, after 110 sessions of exposure to the signaled conditions, there was a strong sequence effect. In fact, the last condition of the previous phase was precisely an A condition in which the signaled response requirements resulted in escape behavior, exactly the type of performance observed in this first unsignaled response-requirement condition of this second experimental phase. The second A condition of this experiment is really intriguing because in three out of four subjects the percentage of trials with persistence was relatively high. This result was completely predictable by Navarro and Fantino as the outcome of the high uncertainty involved in the task, and supports the sequence-effect explanation of the results as previously described because this condition was preceded by 60 sessions with unsignaled presentations of the response requirements. Although in the third exposure to the A condition a high percentage of trial with persistence should have been observed, for three of the subjects the dependent variable decreased systematically as the sessions of exposure to the condition elapsed. This last result is difficult to explain but could be another type of sequence effect given that the previous condition reinforced persistence behavior until a relatively long response requirement was reached, and in this last condition the reinforcer was available after a very short response magnitude.

By contrast with the previous result, the B and C conditions in which persistence was the optimal choice as defined by the arrangements of FR response requirements and probabilities, the four subjects persisted consistently in most of the sessions in the two conditions. This procedure and results could be considered as an extension to an unsignaled situation of the signaled persistence-optimal condition as define by Navarro and Fantino in their Experiment 2. In fact, the unsignaled persistence-optimal C condition of this second phase is interesting if it is compared with the C condition of the previous signaled persistence-optimal condition considering the following rationalization. It seems that the lack of the stimulus increased the uncertainty involved in the task and minimized the contribution of the relative response magnitude which could be important to explain the impulsive behavior observed in the C condition of the first phase of this experiment. This last conclusion seems contradictory with the previous one regarding the response magnitude contribution to the impulsivity involved in the task. However, the comparison between the two C conditions of the present experiment suggests that not only optimal escape or persistence behavior is facilitated by a stimulus signaling the response requirement changes but also the presence or absence of an impulsivity effect depends of the stimulus presentation. That is, it should be noted that given that the arrangement of probabilities of the FR response requirements, to persist was the optimal option and to escape was an instance of impulsive behavior. Therefore, the present results show that, although the same relatively long FR 80 was the most probable in both, the signaled and the unsignaled conditions, the degree of persistence behavior or its opposite impulsive behavior depended of signaling or not the FR response requirements.

Finally, from the comparisons between the results of the two phases of the present experiment and Experiments 1 and 2 from Navarro and Fantino, it could be concluded that effectively the relative frequency of the response-requirements, as established by the different probabilities of presentation of each one, modulates the occurrence of escape-optimal or persistence- optimal behavior and of impulsive behavior. These findings could also be controlled by the presence or absence of a stimulus signaling the response requirements changes.

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