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Rats are optimal in a choice task in which pigeons are not

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ABSTRACT

In an extensive list of studies, it has been found that pigeons prefer an alternative associated with discriminative stimuli over another associated with non-discriminative stimuli, even when the probability of reinforcement is higher in the latter. This behavior has been named "suboptimal choice". In the present experiment, we evaluated whether rats, another widely studied species within the Experimental Analysis of Behavior, also shows this behavior. We systematically replicated the procedure employed with pigeons, and found that rats are not suboptimal, i.e., they prefer the non-discriminative alternative associated with .5 probability of reinforcement, over the discriminative alternative associated with .2 probability of reinforcement. This effect occurred even though rats discriminated the contingencies of reinforcement associated with each stimulus, suggesting that rats' optimal choice was driven by the overall probability of reinforcement of each alternative. Different procedural details are offered as possibilities for explaining this apparent inter-species difference.

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1. Introduction

One of the central implicit assumptions of the Experimental Analysis of Behavior is that the mechanisms controlling choice behavior are the result of natural selection processes that ensure their optimality (Fantino and Logan 1979). This hypothesized optimality has been empirically demonstrated in a variety of foraging situations (Stephens and Krebs 1986), and some behavioral mechanisms that allow reaching it have been proposed (Shettleworth 2010; Fantino and Abarca 1985). In this context, explaining the empirical evidence of non-optimal behavior is an intellectual challenge for the Experimental Analysis of Behavior.

Concurrent-chain schedules are one of the most employed procedures for research on choice behavior. Among the many topics studied with this reinforcement schedule, one that continues generating interest is related to the effect of differentially signaling the possible outcomes associated with the terminal links (TL). Consider, for example, a concurrent-chain schedule in which the two TLs are associated with reinforcement 50% of the time and with a blackout the other 50%; if one of the TLs presents stimuli correlated with the outcome (v.g. red key when a reinforcer will be presented; green key when a blackout) while the other TL presents uncorrelated stimuli, pigeons develop a strong preference for the TL with discriminative stimuli, even though the probability of reinforcement is the same for both alternatives (Green and Rachlin 1977; Roper and Zentall 1999; Bower et al., 1966).

This preference for discriminative stimuli is so strong that the pigeons continue showing it even when the alternative with discriminative stimuli is associated with a lower rate of reinforcement than the non-discriminative alternative (Stagner and Zentall 2010). Recently, a long list of studies (for a review, see Zentall 2014) has shown that pigeons, one of the most studied species within the Experimental Analysis of Behavior, show this non-optimal behavior when evaluated in a choice procedure that presents the following alternatives (see Fig. 1, left panel):

Alternative (1) $p = .2$ of presenting stimulus A, which is associated with the delivery of a reinforcer 10 s later, with probability (p(rf)) of 1.0; and $p = .8$ of presenting stimulus B, which is associated with p(rf) = 0.0, also 10 s later.

Alternative (2) $p = .2$ of presenting stimulus C, and $p = .8$ of presenting stimulus D, which are both associated with p(rf) = .5, 10 s later.

Given that alternative 1 is associated with a net probability of reinforcement of .2, while alternative 2 is associated with a net probability of reinforcement of .5, choosing alternative 1 is considered a non-optimal behavior.

Extensive research in this choice situation and others with similar characteristics (Zentall and Stagner 2011), has shown that pigeons have a strong and consistent preference for Alternative 1, the non-optimal. Other studies have focused on variables capable of modulating the choice of the suboptimal alternative, demonstrating, for example, that a higher proportion of choice of the

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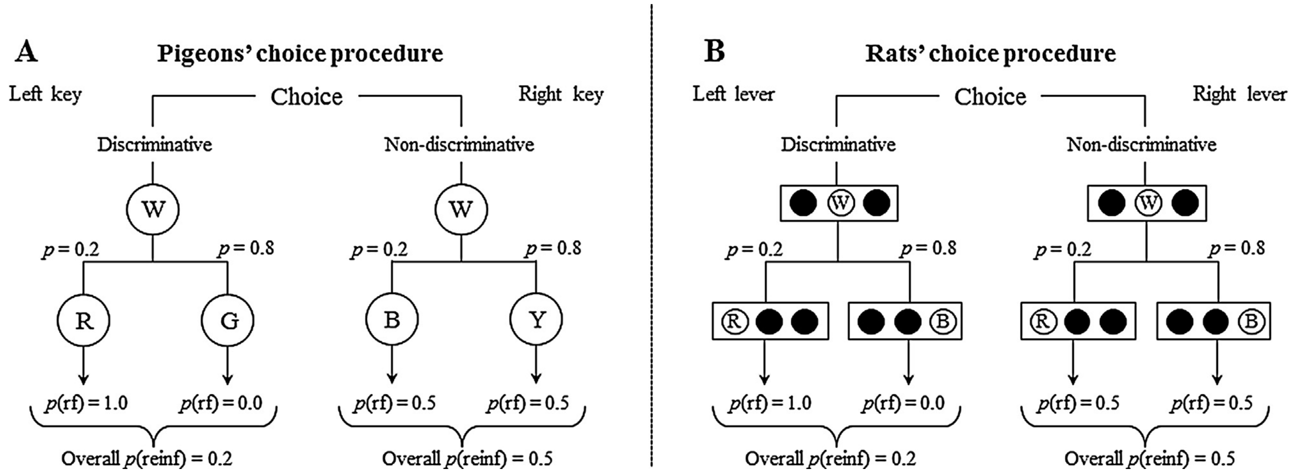

Fig. 1. Panel A: Suboptimal choice procedure for pigeons. When pigeons chose the left white (W) key (discriminative option) then either a red light (R) always followed by a reinforcer turned on 20% of the time, or a green light (G) never followed by a reinforcer turned on 80% of the time; when pigeons chose the right white key (the non-discriminative option) then either a blue light (B) turned on 20% of the time, or a yellow light (Y) turned on 80% of the time. Both blue and yellow were followed by a reinforcer 50% of the time (see Stagner and Zentall, 2010). Panel B: Suboptimal choice procedure for rats. Rats' choice of the left lever, signaled by the white light (W) located in the center of the left triple stimulus display (discriminative option) could lead to: (a) the left red light (R) in the left triple stimulus display 20% of the time; this stimulus was always followed by a reinforcer; (b) the right blue light (B) in the left triple stimulus display 80% of the time; this stimulus was never followed by a reinforcer. Choice of the right lever (non-discriminative option) could lead to: (a) the left red light in the right triple stimulus display 20% of the time, or (b) the right blue light in the right triple stimulus display 80% of the time. Both stimuli were followed by a reinforcer 50% of the time.

non-optimal alternative is associated with a higher level of impulsivity, defined as preference for smaller-immediate reinforcers over larger-delayed ones (Laude et al., 2014a).

In the present experiment, we were interested in evaluating whether rats also show the pigeons' non-optimal behavior recently described. This hypothesis seems worthy of evaluation, given that important differences between the choice behavior of rats and pigeons have been reported in other choice procedures involving conditioned reinforcement (Mazur, 2007, 2005, 1989). Besides getting information about the generality of this phenomenon, an adaptation of the procedure for rats would facilitate the integration of the study of non-optimal behavior with the neurobiological research interested in the study of impulsivity, which employs rats as one of its most relevant models (e.g., Cardinal et al., 2001).

2. Method

2.1. Subjects

Eight Wistar male rats were employed. Subjects were 180 days old at the beginning of the experiment. Rats were housed in groups of four, and placed on a food restriction schedule to maintain them at approximately 85% of their free-feeding weight; this was done by gradually reducing their food intake over a period of seven days. Then rats were fed a limited amount of laboratory chow per day, until the end of the experiment. Water was available ad lib in the home cage.

2.2. Apparatus

Eight operant conditioning chambers (MED Associates, Inc., Model ENV 008-VP) with 2 retractable levers were used. The presentation of stimuli and the collection of data were controlled by personal computers using the Medstate programming language. Each lever was associated with a triple stimulus display that was mounted 1.5 cm above it; each triple stimulus display consisted on a bar of acrylic mounted on an aluminum bar with three apertures of 1 cm of diameter and separated by 0.6 cm, and it could project (from left to right) red, white or blue light via ultrabrilliant LEDs (for a full description of apparatus, see Orduña et al., 2013).

2.3. Procedure

2.3.1. Pretraining

Subjects were trained to press the levers when either of the lights above them was present. The reinforcer was delivered according to a fixed interval 10 s schedule. Each pretraining trial was as follows: a light from one of the two triple stimulus displays turned on and its corresponding lever inserted; the first response after 10 s turned off the light, retracted the lever, turned on a light over the food cup and delivered one 45 mg pellet (Bio-Serv, Product F0165). Three seconds later an intertrial interval (ITI) 10 s long followed, in which all lights were turned off, and a new trial began after that. Only one light per trial was presented. Each of the 6 lights was presented 10 times, for a total of 60 trials per session. All subjects were pressing both levers consistently after two sessions.

2.3.2. Phase 1: training

During training, there were two types of trials: forced and choice trials (see Fig. 1, right panel). In forced trials, only one of the two levers was inserted and its corresponding white light (located in the center of the triple stimulus display) was turned on. One lever press turned off the white light and turned on a side light. If it was the discriminative option, one of its side lights (v.g. red, left) turned on 20% of the trials and reinforcement was delivered 10 s later (i.e. D_{100}); and the other side light (v.g. blue, right) turned on the remaining 80% of the trials and 10 s later the trial ended without reinforcement (i.e. D_0). If it was the non-discriminative option, then one of the side lights (v.g. red, left) turned on 20% of the trials (i.e. ND_{20}) and the other light (v.g. blue, right) turned on the remaining 80% of the trials (i.e. ND_{80}); after 10 s, reinforcement was provided with $p = .5$ with either light. Therefore, reinforcement occurred with $p = .2$ for the discriminative option, and with $p = .5$ for the non-discriminative option. Trials were separated by 10 s ITI.

Assignment of option types to left-right sides was counterbalanced across subjects. There were 20 discriminative (4 D_{100} trials, 16 D_0 trials) and 20 non-discriminative forced trials (4 ND_{20} trials, 16 ND_{80} trials), for a total of 40 randomly alternated forced trials per session.

There were 20 choice trials randomly mixed among the forced trials; in them, both options were simultaneously presented and

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