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Optimal behavior by rats in a choice task is associated to a persistent conditioned inhibition effect

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ABSTRACT

When given a choice between an alternative with a low probability of reinforcement and discriminative stimuli, and another with a higher probability of reinforcement and non-discriminative stimuli, pigeons show a clear preference for the former but rats clearly prefer the later. It has been reported that pigeon's suboptimal choice is associated to a diminishing effect of the stimulus correlated with non-reinforcement. In the present paper, we explored the possibility that rats' optimal choice is more strongly influenced than pigeons' by the stimulus associated to non-reinforcement and that the effects of it do not dissipate during training. We trained rats to choose between an alternative with 0.50 probability of reinforcement and discriminative stimuli, and an alternative with 0.75 probability of reinforcement and non-discriminative stimuli. We replicated the strong preference for the optimal alternative. Then, after several sessions of training, we presented summation trials in which both the stimulus associated to reinforcement and the stimulus associated to non-reinforcement were simultaneously presented. The results showed that the stimulus associated to non-reinforcement exerted a strong effect on choice, and, more importantly, that it did not seem to dissipate across training. These results suggest that the strong difference found between pigeons and rats in the suboptimal choice procedure is potentially related to differences in the impact of conditioned inhibitors.

1. Introduction

Understanding choice behavior has been central to the scientific goals of the experimental analysis of behavior. Given the assumption and empirical evidence about the effects of natural selection processes on the optimality of the mechanisms controlling choice (Fantino and Abarca, 1985; Stephens and Krebs, 1986), the evidence of non-optimal choice behavior has represented an intellectual challenge for this discipline.

One of the most recent examples of non-optimality has been obtained with the "Sub-optimal choice procedure" (for a review, see Zentall, 2016). In this procedure, an organism is faced with a choice between an option that results in a reinforcer 20% of the time, and another option that results in a reinforcer 50% of the time. A crucial aspect of the procedure is that the 20% option has discriminative stimuli that signal when a reinforcer will be delivered and when it will not, whereas the stimuli of the 50% option are not discriminative of the outcome. Since the option with discriminative stimuli results in less reinforcer deliveries than the option with non-discriminative stimuli, choosing the 20% discriminative option has been named suboptimal choice. Studies with this and similar procedures have shown that pigeons (for reviews see McDevitt et al., 2016; Zentall, 2016), monkeys (Blanchard et al., 2015) and European starlings (Vasconcelos et al., 2015) choose suboptimally, showing the generality of this phenomenon; however, Trujano and Orduña (2015) demonstrated that rats prefer the 50% non-discriminative option, i.e., rats are optimal in this choice task.

Several studies have been conducted to understand the variables related to suboptimal choice in pigeons. In one of these studies (Laude et al., 2014), it was reported that early in training, during the few sessions that subjects were optimal, the stimulus associated to non-reinforcement exerted a strong influence on choice, counteracting the effect of the stimulus associated to reinforcement; however, as training progressed the impact of the stimulus associated to non-reinforcement dissipated and subjects became suboptimal. Given this negative correlation between the impact of inhibitors and suboptimal choice, we hypothesized that rats' optimal choice is related to a stronger and more perdurable effect of the conditioned inhibitors. There are several reports of differences between pigeons and rats (Mazur, 2005, 2007; Mazur and Biondi, 2011; Trujano and Orduña, 2015), which have in common that rats' choice behavior seems to be driven by the variables that determine

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the rate of reinforcement, while pigeons are more sensitive to variables related to conditioned reinforcement. In the present report, we were interested in evaluating whether rats show a different pattern of conditioned inhibition than pigeons, which could partially explain their optimality in the "suboptimal choice procedure".

2. Method

2.1. Subjects

Eight male Wistar rats were employed in this experiment. Subjects were 40 weeks old at the beginning of the experiment. They were housed in groups of four, and placed on a food restriction schedule to maintain them at approximately 85% of their free-feeding weight. They were fed a limited amount of laboratory chow at the end of the experimental sessions. Water was freely available in the home cage. The experiment followed the official Mexican norm NOM-062-ZOO-1999 'Technical Specification for Production, Use and Care of Laboratory Animals'.

2.2. Apparatus

Eight operant conditioning chambers (MED Associates, Inc.,Model ENV 008 VP) were employed. Each operant chamber measured 30.5 cm (long) × 24.1 cm (wide) × 21.0 cm (tall), and was enclosed in a sound attenuating cubicle (MED Associates, Inc., Model ENV–022 M). The floor was a stainless steel grid comprised of nineteen 0.5 cm diameter bars (MED Associates, Inc., Model ENV-005). Each chamber had two retractable response levers (MED Associates, Inc., Model ENV 112CM) located 2.1 cm above the floor, in the front wall. Each lever was 4.8 cm wide. Above each lever, there was a triple-stimulus display, which 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. A 5.1 cm × 5.1 cm reinforcer receptacle (MED Associates, Inc., Model ENV-200R2 M) was located in the center of the front wall, 2.5 cm above the floor, and received, according to the schedule, a 0.08 ml drop of milk with sugar (15 g of sugar dissolved in 200 ml of milk). Presentation of stimuli and data recording were controlled by a personal computer using the Medstate programming language (Med-PC-IV, MED Associates, Inc.).

2.3. Procedure

2.3.1. Pretraining

After subjects were shaped to press the levers (for details, see Orduña, 2015), during two sessions they were trained to press them only when either of the lights above them turned on. During each pretraining trial, a light from one of the two triple stimulus displays turned on and its corresponding lever was inserted; the first response after 10 s turned off the light, retracted the lever, turned on a light over the food cup and delivered the reinforcer. 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. 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 seven sessions.

2.3.2. Suboptimal choice training with fixed time schedules in the terminal links

This phase consisted of the presentation of two types of trials: forced and choice trials (see Fig. 1A). During forced trials, only one of the two levers was inserted and its corresponding white/center light turned on (the location of the light – left, center, or right- makes reference to each triple-stimulus display). One lever press

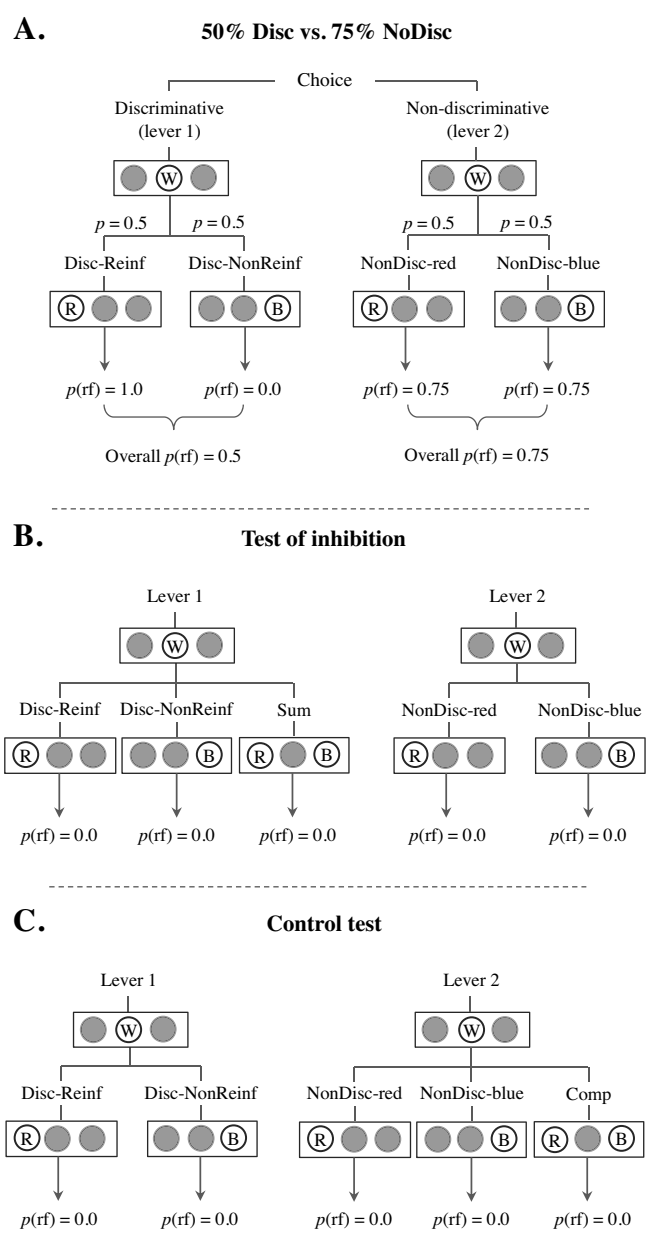

Fig. 1. Diagram of the experimental procedure during the different phases of the experiment. Panel A: Contingencies of reinforcement associated to each stimulus at both options during training. Panel B: Types of trials during tests of inhibition. Panel C: Types of trials during the control test. The schedule of reinforcement employed in each condition differed as described in the text. W = white light; R = red light; B = blue light; Disc-Reinf = Discriminative associated to reinforcement; Disc-NonReinf = Discriminative associated to non-reinforcement; Sum = Disc-Reinf + Disc-NonReinf; NonDisc-red = Non-discriminative red; NonDisc-blue = Non-discriminative blue; Comp = NonDisc-red + NonDisc-blue; p(rf) = probability of reinforcement.

turned off the white/center light and turned on either of the two side lights, which were associated to the terminal links (TL). If it was the discriminative option, the red/left light turned on 50% of the trials and reinforcement was delivered 15 s later; the blue/right light turned on the other 50% of the trials, and 15 s later the trial ended without reinforcement. The red/left light served as a discriminative stimulus for reinforcement (Disc-Reinf), and the blue/right served as a discriminative stimulus for non-reinforcement (Disc-NonReinf).

In the forced trials of the non-discriminative option, a lever press turned on the red/left light on 50% of the trials (NonDisc-red)