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Response factors in delay discounting: Evidence for Pavlovian influences on delay discounting in pigeons

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ABSTRACT

Pigeons completed a delay-discounting task where in different conditions the required response was either key pecking or treadle pressing. Because of stimulus–reinforcer relations that are known to form between localized visual cues and the delivery of food (e.g., autoshaping), we predicted that there would be steeper rates of discounting with key pecking than treadle pressing. To account for possible effort differences between key pecking and treadle pressing, pigeons also completed a discounting task where multiple key pecks were required to gain access to the food. The rates of discounting for the key peck and effort-equivalence discounting procedures were similar, and both were steeper than the rate of discounting for the treadle-pressing procedure. While it is tacitly assumed that behavior in choice situations is largely under the control of operant contingencies, the present results suggest that when developing animal analogs to study discounting in a discrete-trial choice procedure, the stimulus–reinforcer relations (Pavlovian conditioning) may need to be taken into consideration.

1. Introduction

Choice is often studied in terms of delay discounting, which refers to the decrease in the present subjective value of a reinforcer with an increase in the delay to receiving that reinforcer (e.g., Green and Myerson, 2004; Rachlin, 2006). A growing body of literature demonstrates that delay discounting is a cross-species phenomenon (e.g., Freeman et al., 2009; Green et al., 1994, 2004; Mazur, 1987; Rodriguez and Logue, 1988). The pattern of delay discounting across species is well described by the following hyperbolic function:

$$V = \frac{A}{1 + kD}$$

where V represents the present subjective value of a reinforcer, A refers to the amount of the reward, D represents the delay to receipt of the reinforcer, and the parameter k is a free parameter and quantifies the steepness of discounting (Mazur, 1987).

Although cross-species similarities in discounting are present, some species differences exist. For instance, past research has shown that pigeons tend to discount delayed reinforcers more steeply than other species (Mazur, 1987; Tobin and Logue, 1994; Green et al., 2004; Mazur, 2005). Green et al. (2004), for example, used the same temporal-discounting procedure with rats and pigeons and found that though both species discounted delayed reinforcers in a way well described by a hyperbolic function, pigeons, consistently showed steeper rates of discounting than rats.

It is likely that multiple factors contribute to the relatively steep rate of discounting demonstrated by pigeons. For instance, pigeons may have evolved under environmental food source pressures where consistently choosing the immediate smaller option led to an increase in the likelihood of survival. As a result of variable environmental pressures and the resulting evolutionary adaptations, there may be large metabolic differences across species (e.g., Jetz et al., 2008) that could contribute to the heightened valuation of the smaller, more immediate reinforcer. It is also possible that the design of the discounting-task may contribute to the high rates of discounting observed in pigeons (i.e., it is a procedural artifact). For example, a key peck to the smaller-sooner alternative typically results in darkening of the key-light, a very brief (~0.5 s) illumination of a stimulus light, followed immediately by the presentation of food, whereas a key peck to the larger-later alternative results in darkening of the key-light, an extended illumination of a stimulus light (e.g., 20 s), which is then followed by the presentation of food. Because the smaller-sooner reinforcer is received almost immediately following a response in a delay-discounting paradigm, the stimulus–reinforcer relation of responses to the smaller-sooner option is stronger than that of responses to the larger-later option.

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When considering the temporal relation between the stimulus (i.e., illuminated response key) and reinforcer delivery, there is a relatively strong contiguous relation associated with the smaller-sooner alternative. Using a trace-conditioning procedure, past research has demonstrated that a stimulus–reinforcer relation is strongest when the delay to the reinforcer is minimal (Lucas et al., 1981). In a discounting paradigm, a strong contiguous relation between the key-light and the smaller-sooner reinforcer may lead the pigeon to reflexively peck the key associated with the immediate reinforcer whereas; the relationship between the larger-later reinforcer and the key-light is weaker. Because of the close temporal relationship between the key-light and the smaller-sooner reinforcer, the stimulus associated with the smaller sooner reinforcer may be more likely to elicit a response. The close temporal relationship may conflict with the purpose of a free-choice trial because of the way the stimulus associated with the smaller-sooner reinforcer has a greater likelihood of eliciting a pecking response than the stimulus associated with the larger-later reinforcer.

There is research suggesting that the behavior of pecking in particular may be sensitive to Pavlovian conditioning (i.e., the strength of the stimulus–reinforcer relationship). Lapatto and Lewis (1985) and Poling et al. (1985) found evidence to indicate that Pavlovian conditioning influenced responding on a single-key self-control procedure. For instance, Lapatto and Lewis found evidence that under an omission procedure, response-independent food delivery maintained responding when the choice signal was the key light, but not when the choice signal was a tone. These results suggest the behavior of pecking, initially thought to be under the control of operant contingencies, may be influenced by Pavlovian conditioning.

The differential categorization of response type is further supported in the literature investigating behavior under the control of multiple schedules (e.g., Brown and Jenkins, 1968; Schwartz and Gamzu, 1977; Westbrook, 1973). For example Green and Rachlin (1975) studied pigeons on a multiple schedule where the components were a VI 2-min schedule of reinforcement and a VI 2-min + VT 15-s schedule of reinforcement. They found that at points of transition to higher rates of food delivery (e.g., when the VT 15-s was added to one of the components of the multiple schedule), there was a marked and transient increase in responding. Green and Rachlin suggested that through several pairings of key light presentation (the conditioned stimulus) with food delivery (the unconditioned stimulus), the illumination of the key light began to elicit a pecking response (a conditioned response) toward the illuminated key. That is to say, after several transitions from lower to higher rates of food delivery, pigeons' key pecking was elicited in a direction toward the localized visual cue associated with the higher rate of food delivery (i.e., autoshaping).

Since then, researchers have been able to replicate the results with key pecking but not with an alternative response. For example, Green and Holt (2003) expanded on the study by Green and Rachlin by comparing rates of key pecking to rates of treadle pressing under multiple schedules of reinforcement. Green and Holt were able to replicate the results with key pecking, but not with treadle pressing. Under an otherwise identical critical phase of the experiment (i.e., the addition of response-independent food deliveries to one of the components), pigeons treadled less in the presence of the signal associated with the response-independent food deliveries but rates of key pecking increased under the same schedule of reinforcement. The pattern of results observed with treadle pressing are consistent with what would be predicted from operant conditioning, while the results observed with the pecking response are consistent with Pavlovian conditioned response. That is, the key pecking response is influenced by the stimulus–reinforcer relationship while the treadle pressing response is influenced by the response–reinforcer relationship.

The present study investigated whether the influences of Pavlovian conditioning found when using multiple schedules of reinforcement could be extended to a discrete-trial arrangement used to investigate delay discounting with pigeons. To address this question, pigeons completed an adjusting-amount procedure (Green et al., 2004) where the required response type (key pecking and treadle pressing) varied across conditions. We predicted that, regardless of the required response type, increases in delay to food delivery on the larger-later alternative would be associated with an increase in responding on the smaller-sooner alternative (i.e., pigeons would discount the value of a larger-later outcome). We also predicted steeper rates of discounting with key pecking than with treadle pressing based on the hypothesis that the Pavlovian conditioning would increase the likelihood of pigeons pecking the choice alternative with the strongest stimulus–reinforcer relation (i.e., the smaller-sooner alternative).

Pigeons also completed an effort-equivalence procedure where completion of a fixed ratio (FR) schedule was required to gain access to food. The FR requirement was established individually for each pigeon using a procedure that produced an estimate of the number of key pecks equivalent to a single treadle press. This was done in an attempt to rule out the potential confound of effort differences between the response requirements (i.e., it was assumed that key pecking requires less effort than treadle pressing for the pigeon). The FR requirement was an important manipulation because any differences in the degree of discounting between key pecking and treadle pressing could also be explained in terms of the effort required to emit the response (e.g., Chelonis et al., 1998; Floresco et al., 2008; Grossbard and Mazur, 1986). If the type of the response requirement (and not effort) was at least partially responsible for differences in discounting, then we would expect to find steeper discounting with key pecking than with treadle pressing, even with the additional response requirement.

2. Method

2.1. Subjects

Seven white Carneaux pigeons were housed individually and maintained at 80–85% of their free-feeding body weights by means of supplemental feedings immediately after each daily session. Water and grit were continuously available in their home cages, which were housed in a room on a 12:12 h light/dark cycle. The sex of the pigeons was unknown. At the beginning of the study, pigeons were over 5 years old, and each had some history with a choice procedure and were previously trained to respond to illuminated response keys. None of the pigeons had previous experience with treadle pressing.

2.2. Apparatus

Three different test chamber arrangements were used in the present study; key-peck chamber, treadle-press chamber, and effort-discounting chamber. Each chamber (30 cm long by 25 cm wide by 30 cm high) was placed within a light- and sound-attenuating enclosure with a ventilating fan running continuously. Chamber floors were stainless steel grids. Each chamber was equipped with a closed-camera video system, which permitted every session to be viewed on a monitor in an adjacent control room. This allowed for ongoing viewing of environmental events and pigeon behavior.

Key-peck chambers contained one houselight centered on the rear wall and 2 cm from the top of the chamber. Three response keys, each 2.5 cm in diameter, were spaced equidistantly and located on the front wall 8.5 cm from the top of the chamber. The left