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The role of context in risky choice

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ABSTRACT

Human choice behavior was assessed in a concurrent-chain schedule, where two equal initial links (IL) each led to a distinct terminal-link (TL). One TL was associated with a fixed ratio schedule of reinforcement, while the other was associated with a bi-valued mixed ratio schedule of reinforcement, whose arithmetic mean equaled the Fixed TL schedule. The fixed component (FR50; FR25; FR5) was arranged to be equal to the alternative mixed component in each condition (FR1/99; FR1/49; FR1/9), and choice behavior was measured by proportion of responses to each IL. In addition, the IL duration varied across conditions (VI 30 s; VI 15 s; FI 1 s). Preference for the mixed option was observed with longer durations (e.g., when IL = VI 30 s and TL = FR1/99). Participants were relatively indifferent in other conditions, though the results suggested a monotonic increase in preference as either durations or programmed efforts increased. It is concluded that both choice and the conditioned reinforcement value of the mixed option is contextually based, so that the value of a stimulus correlated with an immediate reward (i.e., FR 1) is enhanced the greater the temporal context in which the FR1 is embedded.

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1. The role of context in risky choice

Risky-choice behavior is of great interest to researchers in many fields most notably behavioral psychology and economics, where a choice is made between two options, one certain and the other uncertain. Much work has been done with humans on decision-making under uncertainty, for example Prospect-Theory (Kahneman and Tversky, 1979) while behavioral studies have addressed this issue with non-human subjects (Fantino, 1967; Sherman and Thomas, 1968; Rider, 1983). While there is no standard definition, the term "risky choice" in the current experiment is empirically defined as a choice between two options, one fixed and the other variable (in terms of the reinforcement schedule parameters, not reinforcer amount). Results from behavioral studies involving human choice between fixed vs. variable options have differed, where there is some evidence that humans prefer the variable option (Locey et al., 2009), the fixed option (Kohn et al., 1992) and also evidence indicating that they are indifferent (Weiner, 1966). In particular, the immediacy by which a variable schedule will provide reinforcers seems to be an important determinant of choice (Locey et al., 2009). It is hypothesized that the reinforcing value of a stimulus (when paired with an immediate reward) is relative to its context; meaning that the value of a stimulus (as measured by choice) depends not only on its correlation with immediate reward, but also on its relative immediacy or discriminability from surrounding stimuli and their contingencies.

Behavioral experiments have studied risky choice by offering the choice between two routes to reinforcement, one fixed and the other variable, in terms of time-based delay (Cicerone, 1976; Locey et al., 2009) or response requirement (Fantino, 1967; Sherman and Thomas, 1968; Rider, 1983). Results from non-human studies have consistently found strong preference for the "variable" outcome, when overall reinforcement rate was held constant between the two outcomes.

It has been suggested that a major controlling variable in preference for the variable option is the presence of short-delay reinforcers, as discussed by Locey et al. (2009). However, the surrounding context is of great importance in determining the potency of the stimulus paired with short-delay reinforcement, and even the term "short-delay" can be said to be relative to the surrounding temporal context, where the term "context" is used to refer to the surrounding program values.

Research on choice between fixed vs. variable delay/effort in non-humans has determined fairly conclusively that the variable option is preferred to an equivalent fixed schedule of reinforcement. There is a large body of research on choice behavior using the concurrent-chain procedure (see Fantino and Logan, 1979), where preference for different alternatives to reward can be assessed. Two major contextual variables in a concurrent-chain schedule are duration of the initial links, and the schedule values of the terminal links. One early study found that when choosing between a fixed interval and a variable interval schedule with the same mean

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value, pigeons prefer the terminal-link option leading to the variable schedule (Herrnstein, 1964).

Fantino (1967) utilized a concurrent-chain schedule to determine choice between a fixed ratio (FR) vs. a "mixed ratio" (MR) requirement using pigeons. A FR schedule is a schedule of intermittent reinforcement providing reinforcement upon completion of a fixed number of responses. In this case, the MR consisted of a randomly alternating bi-valued ratio schedule, where no exteroceptive stimuli indicate which ratio value is in effect. The terminal links were programmed as either a FR schedule or a MR schedule of reinforcement. Upon completion of food intake the initial links resumed, beginning the next trial. Choice behavior is measured by the proportion of responses to each initial-link stimulus, where greater responding toward one stimulus indicates preference (and therefore greater conditioned reinforcing value) for its corresponding terminal-link.

Fantino (1967) exposed pigeons to a concurrent-chain schedule where one terminal-link was a MR schedule of values 1/99, 10/90, or 25/75, and the other terminal-link was the arithmetic mean, FR 50. In all three conditions, birds preferred the initial-link associated with the MR terminal-link. This demonstrates that the MR stimulus had a greater conditioned reinforcing value. In fact the 1/99 MR was preferred even when the FR was as low as FR 20. The current study is similar to Fantino (1967) with the use of the concurrent-chain design and attempts to clarify how the conditioned reinforcement value of a stimulus paired with immediate reinforcement (i.e., FR1) in humans is a function of context, by manipulating initial-link and terminal-link values.

Research on choice between fixed and variable outcomes has also involved temporal delay of reward. For example, one experiment had rats choose in a Y-maze, between a constant delay of 15s to food, and a delay of either 0 s or 30 s (Pubols, 1962). Rats strongly preferred the arm associated with the variable delay to reinforcement. A study involving pigeons sought to determine whether constant or variable delay to food reward was preferred (Cicerone, 1976). Birds consistently preferred the variable delays, especially when the range of possible mixed values was greater (e.g., 2/14 s delay rather than 6/10 s). One argument for this is that variable schedules inevitably contain shorter-delay (or shorter-effort) reinforcers than the equivalent fixed schedules.

Additional support for this conclusion comes from Sherman and Thomas (1968), where a multiple schedule was arranged consisting of 9 fixed-ratios, each associated with a different stimulus leading to food reward. Pigeons could complete a given FR within the multiple schedule, or by pecking a 2nd key could switch to a variable-ratio (VR) schedule consisting of the same 9 ratios. Results revealed consistent switching behavior toward the VR schedule, although this did not maximize rate of reinforcement. However, when single-response reward opportunities were removed on the variable schedule, subjects decreased their switching to this schedule.

In one of the earliest human studies (Weiner, 1966), participants were offered a choice to switch from a FR to an equal VR schedule (or vice versa) of reinforcement where participants watched videos. Results did not show preferential switching behavior from either schedule to the other, suggesting that participants were indifferent to fixed vs. variable ratio schedules. A more recent experiment by Locey et al. (2009) studied how human participants made choices for delayed access to video clips. In the initial experiment all participants preferred the variable-delay schedule vs. the fixed-delay schedule. In a second experiment, two alternatives were again made available, this time each associated with a variable-time schedule of delay, however one of the alternatives was programmed to have a higher probability of short-delay reinforcers. As was hypothesized, participants preferred the alternative with higher probability of short-delay reinforcers even though reinforcement rate was equated in both alternatives. This finding is consistent with the conclusion that short-delay (or short-effort) reinforcement is a potent contributor to choice in these tasks.

The current study assessed choice behavior for mixed vs. fixed ratio schedules in the context of a concurrent-chain schedule with humans. The two contextual variables manipulated were: (a) duration of initial-link and (b) absolute size of the terminal-link ratio requirement. It was hypothesized that the longer the initial or terminal links, the more salient the FR1 outcome, and the more likely preference would occur for the mixed outcome.

2. Method

2.1. Participants

496 undergraduates from the University of California, San Diego participated in the experiment. Each participated in one experimental session which consisted of a 40-trial choice task. Compensation for participating in the experiment consisted of course credit in undergraduate psychology courses.

2.2. Apparatus

The experimental chamber was a sealed room with four isolated computer stations. There were no windows or decorative items on the walls. One-inch thick wood panels partitioned the four computer stations. A standard computer monitor, keyboard, and a mouse were in front of the participants. Most incidental stimuli were removed from the room.

2.3. Procedure

Participants were led individually into the experimental chamber, contingent on relinquishing: backpacks, cell phones, food or any other distracting stimuli. Experimenters instructed participants to refrain from speaking to others during the experiment and experimenters periodically patrolled to maintain internal validity. Instructions given to participants were as follows:

> The goal of this task is to finish as quickly as you can. Use the mouse to click on the buttons. In the center of the screen will be a progress bar, which represents the time remaining in the task.
> You may click however you like, but it is your job to determine how to use the buttons to reduce the progress bar. Once the progress bar is empty, the task will be complete and you will be notified.

The experiment made use of concurrent-chain schedules of reinforcement, consisting of two equal, independent variable-interval initial links each of which produced a terminal-link stimulus corresponding to a ratio schedule of reinforcement. At the beginning of each trial the two identical white keys at the top of the screen were illuminated. Participants responded freely to either initial link stimulus, where a change over delay of 2 s for initial-link responding was programmed. Upon completion of the interval schedule, a response to either initial-link key produced the terminal-link stimulus corresponding to that option, along with a ratio schedule of reinforcement. A pictorial representation of the concurrent-chain schedule is available in Fig. 1. One terminal-link key was programmed with a bi-valued Mixed (FR) schedule and the other terminal-link key was programmed with a constant FR schedule where the means of the two schedules were equal. The location of the terminal-links was randomly assigned with a 0.5 probability across subjects. A trial was completed when the response contingency in the terminal-link was fulfilled, followed by two events: (1)