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Rule-governed versus contingency-governed behavior in a self-control task: effects of changes in contingencies

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Abstract

Rule-governed behavior is typically acquired faster than contingency-governed behavior but is less sensitive than contingency-governed behavior to unverbalized contingency changes. The present study investigated these relationships in a computer task frequently used to study human self-control. Instructions for one group of participants contained a hint about how to maximize long-term reinforcement; the other group performed the task without the hint. Participants given the hint came closer to maximizing reinforcement in the long term, but their behavior was less sensitive to an unsignaled contingency change than that of those not given the hint. The study shows that, like other complex behaviors, self-control may be contingency-governed or rule-governed.

Keywords: Rule-governed; Contingency-governed; Self-control; Hints; Sensitivity to change; Schedule of reinforcement; Humans

1. Introduction

Contingency-governed and rule-governed behaviors differ in speed of acquisition, maintenance, and response to change in underlying contingencies (Hayes and Ju, 1998). By definition, contingency-governed behavior is acquired and maintained by its current consequences. In contrast, rule-governed behavior is acquired as a result of stated rules—verbal discriminative stimuli for antecedents and consequences that may have been experienced in the past (Brown, 1983; Cromie and Baker, 1997; Joyce et al., 1989; Kerr and Keenan, 1997; Peláez and Moreno, 1998). Thus, these behaviors are acquired through processes that are on the face of it dissimilar.

When rules signal current contingencies behavior usually adjusts faster to those contingencies than when no rules are provided. However, when contingencies are changed without corresponding rule changes, rule-governed behavior is slower than contingency-governed behavior to adjust (Hayes et al., 1986a,b; Hayes and Ju, 1998; Ninness and Ninness, 1998; Shimoff et al., 1981, 1986).

The sensitivity of rule-governed behavior to contingency changes appears to be affected by

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factors such as reinforcement schedules, accuracy of rules, previous experience with rules, and reinforcer potency (Baron and Galizo, 1983; Kerr and Keenan, 1997; Ninness and Ninness, 1998; Warry et al., 1999). For example, continuous reinforcement schedules, which allow frequent contact with underlying contingencies, enable the accuracy of rules to be tested. Rule-governed behavior, established under such schedules, is more sensitive to change in non-verbalized contingencies than is rule-governed behavior established under more diffuse reinforcement schedules (Baron and Galizo, 1983; Hayes et al., 1986a,b).

This paper reports a study of the effects of changes in the underlying contingencies of rule-governed and contingency-governed behaviors, using a self-control procedure in which a larger reward is temporally distributed while a smaller reward is immediate (Herrnstein et al., 1993; Heyman, 1996; Kudadjie-Gyamfi and Rachlin, 1996). Self-control is defined as choice of the larger, distributed reward over the smaller, immediate reward (Rachlin, 1995). Most practical self-control problems are of this kind. The alcoholic, for instance, repeatedly chooses between an immediate, clearly defined reward (an alcoholic drink) and a set of vaguely defined but ultimately larger rewards (good health, job success, social acceptability). At any given moment, drinking is preferred to not drinking. But, over time, the rewards contingent on not drinking are preferred (Logue, 1988; Rachlin, 2000).

In the present study, two groups of participants worked to earn money under a complex set of underlying contingencies. Participants could increase their earnings (points exchanged for money) by minimizing the delay between a choice and its outcome. The delay after one alternative was always less than that after the other, but repeated choice of the lesser delay increased future delays for both alternatives. Participants in the rule-governed group were given a verbal hint about the nature of the contingency whereas those in the contingency-governed group were not given the hint. This paradigm, in which local reinforcers are opposed to distributed (global) reinforcers, has proven to be an effective tool for the study of self-control (Herrnstein et al., 1993; Warry et al., 1999).

The present study had two goals: first, to determine whether the provision of salient verbal rules would increase self-control in a distributed choice paradigm. In previous studies with distributed choice self-control tasks Kudadjie-Gyamfi and Rachlin (1996) found that hints only suggesting a relationship between choice and outcome did not increase self-control; Herrnstein et al. (1993) found only a transient effect of hints. In the current experiment the saliency of the hint was increased so as to obtain a more long lasting effect.

Secondly, the present study investigated sensitivity of rule-governed and contingency-governed behavior (in this self-control paradigm) to non-verbalized changes in the underlying contingencies. As previously stated, sensitivity of rule-governed behavior to non-verbalized changes in contingencies depends on many factors. This study seeks to investigate such sensitivity within the context of a paradigm that resembles real-life self-control situations.

2. Method

2.1. Participants

Eighty students enrolled in an undergraduate psychology course at the State University of New York at Stony Brook served as participants. Their participation in the experiment was in accordance with the American Psychological Association's ethical standards for human participants. The participants were randomly divided into two groups of 40.

2.2. Material

A computer program detailing the experimental conditions was installed on a computer to which a small metal box, $7'' \times 8'' \times 5.5''$ was attached. There were two buttons on the upper elevated side of this box. Participants faced the computer screen and had easy access to the keyboard and buttons. Participants were individually tested.

2.3. Procedure

The procedure was used by Kudadjie-Gyamfi and Rachlin (1996) and is a variation of that used by Herrnstein et al. (1993). Participants chose between a more favorable overall alternative (A) and a more favorable local alternative (B) by pressing one of two buttons. Each choice was followed by a delay and rewarded with a single point, its outcome, O (exchangeable for 10 cents). The alternatives differed only in the pre-reward delay after a choice had been made. A counter on the screen indicated the delay-time remaining. When a total delay time of 650 s had elapsed, the experiment ended.

Table 1 indicates the contingencies in effect for the first 325 s of delay time. The delay after an A-choice was always 3 s longer than that after a B-choice. Thus, B was always the immediately better alternative. However, a register in the computer (not shown to the participants) kept a running total of B-choices over the prior 10 trials. As Table 1 indicates, the more B-choices, the greater the delay after both A-choices and B-choices. Consequently, the delay upon choosing a B after ten repeated A-choices was 0 s whereas the delay upon choosing B after ten repeated A-choices was 13 s. Distributions of A-choices and B-choices between these extremes resulted in proportional average delays. For example, the average delay after a 50:50 split between A-choices and B-choices (that is, 5 As and 5 Bs in the register) was 6.5 s (the average of 8 and 5 s). Participants would thus maximize earnings by always choosing A and minimize earnings by always choosing B.

Table 1
Delay of payout as a function of number of Bs in previous 10 trials

Number of Bs	Delay for A (s)	Delay for B (s)
0	3	0
1	4	1
2	5	2
3	6	3
4	7	4
5	8	5
6	9	6
7	10	7
8	11	8
9	12	9
10	13	10

Note: All participants start the experiment with a set of 10 trials entered as ABABABABAB, with an initial delay output of 5 s for a choice of B, and 8 s for a choice of A.

At time $t = 325$ s, that is, halfway through the experiment, the contingencies changed. From $t =$ 325 s to $t = 650$ s, the outcome of choice A or B was determined solely by the number of As and Bs within the set of 10 prior choices made at time $t = 325$ s. That is, the computer register was frozen at whatever payoff values were obtained at time $t = 325$ s. Thus, if there were 5 Bs in this set, for the rest of the experiment, a choice of B would always result in a delay of 5 s, and a choice of A would always result in a delay of 8 s. For the first 325 s, exclusive choice of A would minimize overall delay and maximize points earned. For the next 325 s (i.e. from $t = 325$ s to $t = 650$ s), exclusive choice of B would minimize overall delay and maximize points earned. Thus the best strategy to maximize points earned is exclusive choice of A within the first 325 s and exclusive choice of B within the last 325 s. The participant's task was to make as many points as possible within the 650 s allotted delay time.

Throughout the experiment choice (C) and outcome (O) were grouped in triads. Previous work (Kudadjie-Gyamfi and Rachlin, 1996) suggests that subjects were more likely to choose the self-control alternative when the trials were presented in triads than when trials were presented singly. Each triad was followed by a 30-s intertrial interval (ITI): COCOCO 30″. Participants in the NO-HINT (contingency-governed) group read the following instructions:

> Hi! Welcome to the 'dime-a-point' game. Today we would like you to play our computer game and earn some money.
>
> The way to make money is to get as many points as possible in our game. You have 650 s within which to do this. A 'dime-a-point' is how much we'll pay you when you are through. It may not sound like much, but an expert can make as many as 150 points and can win up to \$15.00 in a short time.

The rules of the game are easy. On the computer screen in front of you is a sample game set up with 10 choices for you to make. Read the rest of the instructions and then you can practice on this sample game. All of your choices will be made with the button box attached to the computer. The left side button is one alternative and the right side button is the other.

You can see that there is one box in the middle of the screen labeled 'choice'. Any choice that you make during the session will count towards your final total. The nice thing about our game is that, at any period in the experiment, you are informed of the total number of points you have made. The left side button and the right side button will each give you the same amount when you press one of them.

Also on the screen is a timer indicating at any time how much time you have left within which to make your points. Your job is to figure out the combination of left and right choices that will give you the highest point total and that will enable you to make the best use of the time.

After you are done with the practice game, follow the instructions on the screen and you will play for real, making as many choices as you can within the time indicated on the screen. If you have any questions about these instructions or how to use the button box, please ask the experimenter.

For the HINT group (rule-governed) the following paragraph was added after 'The left side button and the right side button will each give you the same amount when you press one of them.':

However the rate at which you earn these points depends on your previous combination of left and right choices. As you will see, the left button is always faster than the right. But if you press the left button too much, the future rate for both buttons will decrease.

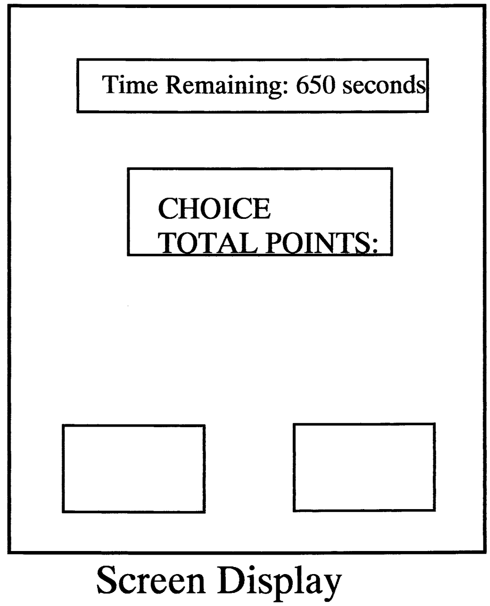

Fig. 1. Subjects saw this display on the computer screen at the onset of the experiment. Information on how much delay time remained, total points earned, and the button which had just been pressed was provided. The pressed button also lit up as the timer counted down after choice of A or B.

The rest of the instructions remained the same.

Participants saw the screen shown in Fig. 1 at the onset of the experiment (with subsequent delay changes appropriately reflected). A button press during a trial had the following consequences: the box on the screen corresponding to the pressed button was lit and remained so while the timer visually counted the delay; an audible high-pitched beep accompanied the visual countdown; and, a point was added to the choice box. Participants were not verbally informed of the ITI. Responses during the ITI, if any, were rewarded with a different color illumination of the box corresponding to the pressed button. A loud low-pitched beep accompanied the illumination, and no point was added to the choice box. The end of the ITI was signaled by a medium-pitched click.

3. Results

Fig. 2 shows total A-choices for the HINT and NO-HINT groups within the first and second

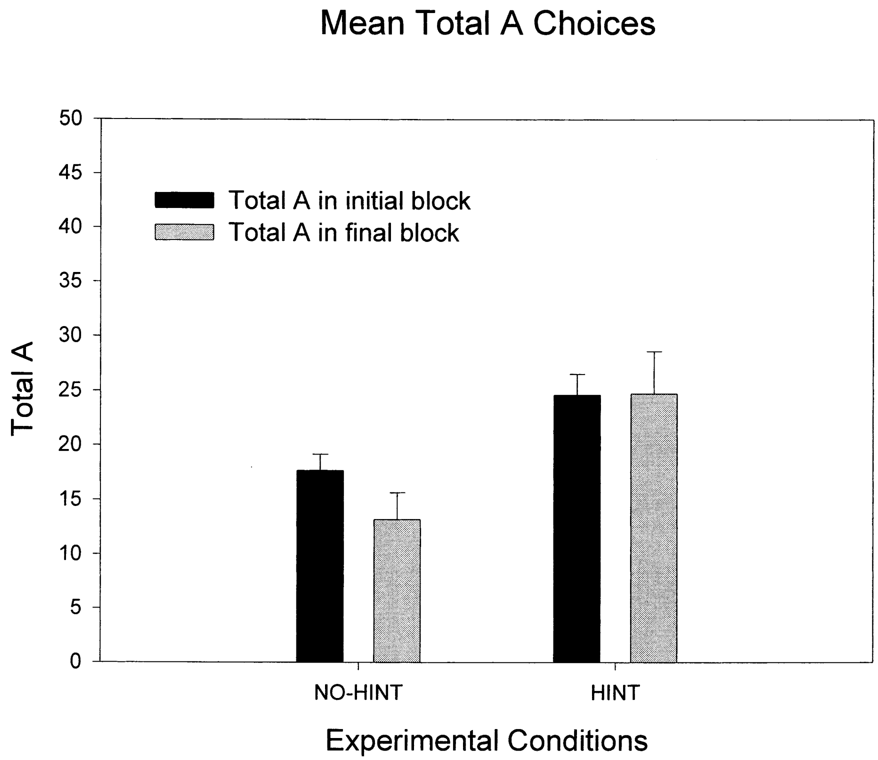

Fig. 2. Mean total A choices made by groups NO-HINT and HINT in initial and final blocks. Dark filled bars represent choices in the initial blocks. Light filled bars represent choices in the final blocks. Vertical lines depict standard error of the means.

blocks of 325 s. The differences depicted between the groups are significant in both initial and final trial blocks (block 1: $t = -2.862$, $P = 0.005$; block 2: $t = -2.514$, $P = 0.014$).

In each of these blocks, participants in the HINT group chose A significantly more frequently than did those in the NO-HINT group.

Participants in the NO-HINT group chose A significantly less frequently in the second block than in the first ($t = 2.017$, $P = 0.025$). This behavior reflects sensitivity to the changed contingencies. Participants in the HINT group, on the other hand, did not differ significantly in their choices from the first block to the second ($t = -0.50$, $P = 0.48$).

Table 2 presents the probability of picking A as the first response in a triad ($P(A)$), the conditional probabilities of an A on the second response given an A on the first (A/A), and an A on the third response given an A on the first and second responses (A/AA). In a previous study (Kudadjie-Gyamfi and Rachlin, 1996) conditional probability of choosing A increased for successive

Table 2
Mean conditional probabilities

Group	$P(A)$	$P(A/A)$	$P(A/AA)$
NO-HINT (initial)	0.3548 ($n = 40$)	0.3981 ($n = 40$)	0.5780 ($n = 30$)
HINT (initial)	0.4759 ($n = 40$)	0.4969 ($n = 40$)	0.4910 ($n = 34$)
NO-HINT (final)	0.2686 ($n = 40$)	0.5198 ($n = 29$)	0.5715 ($n = 23$)
HINT (final)	0.3636 ($n = 40$)	0.4437 ($n = 37$)	0.5833 ($n = 27$)

Note: $P(A)$ is the probability of picking an A as the first response in a triad. $P(A/A)$ is the probability of picking an A on the second response given that an A was selected as the first response. $P(A/AA)$ is the probability of picking an A on the third response given that the first two choices were both As.

choices across the triad. In the present study, conditional probabilities increased significantly across the triad for the NO-HINT group in both initial and final blocks ($t = -1.9577$, $P = 0.03$; $t = -1.759$, $P = 0.044$, respectively). Thus participants who chose A on the first trial of a triad tended to choose A on the second and third trials as well. For group HINT, these differences approach significance (initial block: $t = -1.679$, $P = 0.0512$; final block: $t = -1.718$, $P = 0.0488$).

The only significant difference seen between groups is in the probability of picking an A as the first response in a triad in the initial block. Group HINT was more likely to pick an A on the first response ($t = -2.7278$, $P = 0.0078$).

4. Discussion

Empirical work on rule-governed and contingency-governed behavior (e.g. Shimoff et al., 1981) suggests that provision of rules speeds up initial behavioral adjustment but tends to reduce sensitivity to non-verbalized changes of underlying contingencies.

In the present experiment a one-paragraph hint significantly improved performance on the self-control task. The effect of the hint on A-choices was strong and showed no signs of diminishing over the course of the experiment. In fact, it persisted over a strong contingency change. This finding differs from that of Herrnstein et al. (1993) in which hints in a distributed choice problem only temporarily improved performance. There were several differences in procedure of the two experiments. In Herrnstein et al.'s procedure, participants had 900 s delay time, were paid in coins on the screen, had delay between buttons of 2 s, no intertrial interval, no grouping of trials, and were given one of 3 possible levels of hint—none, medium and strong. In the present experiment, delay time was 650 s, payoff was in points on the screen, delay between buttons was 3 s, choices were in triads, a 30-s intertrial interval was instituted between triads, and a change in the underlying contingencies was instituted halfway through the experiment. Any of these factors or some combination of them may have caused the difference. The HINT group's choices were insensitive to a change from the self-control contingency to a simple choice between short and long delayed reinforcers. (After time $t = 325$ all A-choices were followed by identical delays and all B-choices were followed by delays 3 s shorter.) This result extends findings by Catania et al. (1982, 1989, 1990) and others (e.g. Hayes et al., 1986a) with more or less complex tasks, to tasks involving choice between short-term and long-term reinforcers and thus to self-control.

It may be argued that the problem faced by the participants in this experiment was purely a cognitive problem—determining the actual contingencies—and not relevant to real-life self-control, traditionally considered to be wholly a motivational problem. (Addicts supposedly 'know' what they should do but just do not have the willpower to do it). But none of the participants in this experiment, even those few in the HINT group who consistently chose the distributed reward, could verbalize the contingencies. Moreover, in another experiment with similar contingencies and rewards (points exchanged for money at the end of the session), choice of the distributed reward varied directly with the magnitude of the distributed reward relative to that of the immediate reward (Rachlin et al., 2000); this would not have occurred if the problem were purely cognitive. (Increasing the numbers in a practical arithmetic problem does not make it easier to solve). It may yet be argued that those participants who failed to maximize reinforcement in the present experiment fundamentally failed to understand the contingencies; incentive could just interact with underlying understanding as it frequently does with perception. This is of course possible but so is it possible in everyday self-control, as philosophers have argued since Plato. From a behavioral viewpoint, the interaction between motivation and cognition is not like that between separate mechanisms, regulated in lower versus higher parts of the brain, but rather an interaction of short-term and long-term rewards on the behavior of a whole organism, as studied in this experiment.

The implication of the correspondence between self-control and other behaviors that may be rule-governed or contingency-governed is that the problem of self-control is a problem of making contact with the harmful long-term effects of immediately reinforced acts. The role of societal rules in overcoming lack of self-control may not always be beneficial—especially if contingencies change (by development or through external circumstances) while societal rules remain unchanged.

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