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Contingency Enhances Sensitivity to Loss in a Gambling Task with Diminishing Returns

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Abstract

This study examined whether gambling behavior under conditions of diminishing returns differed between participants with histories of contingent (CD group) and noncontingent (NCD group) token delivery. In Phase 1, CD participants accrued tokens by correctly completing a discrimination task; for NCD participants, token accrual was yoked to token delivery of CD participants. In Phase 2, participants could choose to gamble their tokens or end the experiment and exchange their tokens for money. During the gambling task, participants could bet one token per trial. The probability of losses began at 10% and increased incrementally across blocks of 10 trials up to 100%. Overall, participants in the CD group gambled on fewer trials than participants in the NCD group. Costs of token accrual during Phase 1, in terms of number of trials and duration, showed a positive correlation with net tokens for the CD group but not the NCD group. Results are consistent with previous research demonstrating the value-enhancing effects of both prior contingent delivery and effort, and offer evidence that these histories influence sensitivity to loss.

Keywords

stimulus value; reinforcer value; within-trial contrast; gambling

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Compliance with Ethical Standards

Ethical approval: This article does not contain any studies with animals performed by any of the authors. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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Understanding the determinants of reinforcer value is a fundamental aim of both behavior analytic and behavioral economic research. However, reinforcer value (or more broadly, stimulus value) is not a unitary construct and has been defined and measured in numerous ways. Assessments of relative preference, response rate, behavioral persistence, breakpoint, and demand elasticity have all been used to examine value (Hursh & Silberberg, 2008). Furthermore, value is not static and can be influenced by numerous variables such as deprivation (Michael, 1993), availability of substitutable or complementary reinforcers (e.g., Green & Freed, 1993), delay to or probability of receipt (Green & Myerson, 2004), effort (e.g., Hursh, Raslear, Shurtleff, Bauman, & Simmons, 1988), and many others.

One factor observed to influence the value of a stimulus is whether that stimulus is delivered contingent on behavior. Numerous studies have indicated that contingent delivery of a stimulus is typically preferred to its noncontingent delivery (e.g., Inglis, Forkman, & Lazarus, 1997; Luczynski & Hanley, 2009; 2010). For instance, studies examining the contrafreeloading effect have repeatedly demonstrated that animals will emit behavior to obtain response-contingent food despite noncontingent food being freely available (Osborne, 1977). More recently, Luczynski and Hanley (2009, 2010) demonstrated that preschool children typically preferred situations in which praise or food were delivered contingently over situations in which these reinforcers were delivered noncontingently.

The relation between contingency and stimulus value is a curious one. Although contingent consequences are more preferred, they necessitate behavior on the part of the organism, thus requiring some degree of effort. It has been long established that effort can be an aversive feature of responding that organisms behave to minimize or avoid (e.g., Courtney & Perone, 1992; Perone & Baron, 1980). For example, Miller (1968) manipulated effort by changing the force necessary for human participants to emit responses on mechanical devices and found that participants not only preferred to emit responses of relatively lower effort, but also escaped from schedule components that required relatively greater response effort. Furthermore, increased response effort has been shown to produce punishment-like effects (e.g., Alling & Poling, 1995), clearly indicating the potential aversive properties of effort.

Along with its entanglement with preference for contingent over noncontingent stimulus delivery, other anomalous effects of effort on value have been observed. Of particular interest, investigations of *within-trial contrast* (WTC; Zentall, 2005) and *state-dependent valuation* (Pompilio & Kacelnik, 2005) have demonstrated preference for stimuli previously correlated with relatively higher effort across several species under a variety of preparations (e.g., Alessandri, Darcheville, Delevoeye-Turrell, & Zentall, 2008; Aw, Vasconcelos, & Kacelnik, 2011; Clement, Feltus, Kaiser, & Zentall, 2000; Kacelnik & Marsh, 2002). A common method used to generate these effects involves training two or more chained schedules in which certain stimulus discriminations follow differing amounts of effort (e.g., low effort: fixed-ratio [FR] 1; high effort: FR 20) in a trial-based arrangement and subsequently testing for relative preference among the discriminative stimuli. During these tests, subjects tend to choose the stimulus previously correlated with higher effort, suggesting that historical effort increases stimulus value. Although a number of studies have failed to obtain similar results (e.g., Arantes & Grace, 2008; Vasconcelos, Urcuioli, &

Lionello-Denolf, 2007), much of the research examining this effect has supported this finding (for a review, see Meindl, 2012).

In addition to showing the effect of effort on increased value via relative preference, Johnson and Gallagher (2011) also examined consumption and relative response rate in mice using similar procedures. They found that food previously associated with greater effort was preferred and consumed more relative to food previously associated with less effort. Furthermore, when stimuli that had been paired with each food were presented contingent on responding, higher rates of behavior were observed for the stimulus associated with greater effort. These findings were the first to demonstrate enhanced efficacy of a conditioned reinforcer based on greater effort previously required to obtain the primary reinforcer.

This literature suggests that the value of a reinforcer should increase as a function of the effort previously required to obtain that reinforcer. Similarly, reducing or eliminating the effort required to produce a reinforcer may function to reduce the value of that reinforcer. While the majority of research in this area has demonstrated the value-enhancing effects of prior effort when both schedules required effort (e.g., FR 1 vs. FR 20), few studies have compared histories of contingent and noncontingent delivery. DeLeon, Williams, Gregory, and Hagopian (2005) described data relevant to this issue. For two individuals with developmental disabilities, reinforcer values for two items were assessed using progressive-ratio (PR) schedules to determine breakpoints prior to and following periods of contingent and noncontingent delivery. Under PR schedules, the completion of a ratio schedule results in the delivery of reinforcement and in an increase to the ratio requirement of the subsequent schedule (Hodos, 1961). When responding ceases for a predetermined amount of time, the last completed ratio is considered the breakpoint and serves as a measure of reinforcer value. Relative to the initial assessments, the item delivered contingently to each individual increased in value (higher breakpoint) whereas the item delivered noncontingently decreased in value (lower breakpoint). Extending this research, DeLeon and colleagues (2011) investigated the effects of several types of contingency on reinforcer value. Stimuli identified as moderately preferred were evaluated in terms of relative preference and breakpoints before and after being subjected to one of several conditions for 4 weeks. They found that items delivered noncontingently generally decreased in relative preference, but that breakpoints remained unchanged across assessments. Conversely, stimuli delivered on an FR 1 schedule increased in both preference and maximum responding. However, stimuli requiring increased effort (escalating FR schedules) across deliveries produced mixed results, with decreased relative preference but moderately increased maximum responding. These findings generally support the notion that contingency enhances reinforcer value, but are inconclusive with respect to the effects of effort.

Two recent studies have examined the effects of effort on value in the context of gambling. In one study, Brandt, Szttykiel, and Pietras (2013) evaluated the effects of prior noncontingent delivery (an experimenter-provided allotment) on gambling. Participants could choose to either produce a token or gamble a token to potentially receive a higher payout during two blocks of 30 trials. Prior to either the first or second block, experimenters provided a 30-token allotment (noncontingent delivery). The study found that participants

who received the allotment at the start of the first block gambled more than when no allotment was provided; however, participants who received the allotment at the start of the second block did not gamble more relative to the first block. The authors suggested that less gambling occurred in the second block due to the history of participants obtaining tokens through the task (i.e., contingent on a response) in the first block, thereby producing a durable increase in the subjective value of tokens that countered the effects of the subsequent noncontingent delivery. These data potentially provide some additional evidence that noncontingent delivery of a stimulus decreases its value in that participants were more likely to risk tokens when provided an initial allotment for free; however, the differences in initial amounts of tokens when presented the opportunity to gamble obscure this conclusion.

In the other study, Speelman and Dixon (2014) examined the influence of response effort prior to gambling in a basketball task. In the experiment, participants were assigned to groups in which they either received points noncontingently (no effort), earned 3 points per basket during a 40-s period (low effort), or earned 1 point per basket during a 120-s period (high effort). Subsequently, participants gambled points by shooting 20 baskets of varying difficulty (low-, moderate-, and high-risk) and payoff (1, 2, and 3 points). They found that the most frequent gambles made by the no-effort, low-effort, and high-effort groups were the high-risk, moderate-risk, and low-risk gambles, respectively. These data also potentially support the value-enhancing effects of prior effort; however, several aspects of the procedures introduced potential confounds, particularly that initial amounts of points prior to gambling varied substantially within the low- and high-effort groups, and the probability of each gamble varied based on the skill of the individual participant.

Examining value in a preparation where initial sums prior to gambling and probabilities during gambling are equivalent across participants could provide a more refined picture of the effects of prior effort by eliminating sources of variability. Assessing gambling across a range of probabilities, such as in a context of diminishing returns, could provide additional information similar to breakpoint analyses or demand curves. That is, by exposing participants to numerous probabilities, the point at which a change in responding occurs would be more sensitive than simply identifying whether behavior did or did not occur under a single probability of reinforcement.

A methodology described by Newman, Patterson, and Kosson (1987) may be a suitable means of investigating the effects of contingent delivery while controlling for the aforementioned sources of variability. Newman et al. (1987) presented prisoners with a computerized task to assess the extent to which they persisted in gambling as the probability of reinforcement (monetary gain) decreased and punishment (monetary loss) increased. Participants began the task with 10 poker chips worth 5¢ each and were allowed to gamble one chip per “play.” Each opportunity to gamble began with the computer program asking the participant to press one key if they wanted to play and a different key if they wanted to stop playing and exchange their tokens for money (cash out). If the participant played, a letter or number representing a card from a playing card deck appeared. Face cards (J, Q, K, A) resulted in a win (5¢ chip delivered), number cards (2–10) resulted in a loss (5¢ chip removed). Probabilities of losses increased over the course of the experiment and were distributed randomly within blocks of 10 cards, with 1 of 10 cards producing a loss in the

first block and all 10 cards producing losses in the tenth block. The results of the study indicated differences in the number of cards played between participants who were and were not identified as psychopathic.

Variations of the Newman et al. (1987) procedure have been used in numerous studies as a means of assessing sensitivities to punishment and reinforcement, sometimes referred to as “reward dominance.” Shapiro, Quay, Hogan, and Schwartz (1988) used a similar procedure with adolescents with and without conduct disorders and also found differences in the number of cards played between diagnosis-based groups. Daugherty and Quay (1991) later used a modified version of this task to compare responding between groups of children with and without conduct disorders. The procedure was altered in that the participants were presented doors that they chose whether or not to open. Opening a door then resulted in a gain or a loss according to the same decreasing schedule used in the aforementioned studies.

The current study used a variation of the procedures used by Daugherty and Quay (1991) by arranging for human participants to choose between gambling tokens exchangeable for money and terminating the experiment in the face of an ever-increasing probability of loss. Of primary interest was the extent to which sensitivity to the loss of tokens was a function of whether tokens were acquired contingently or noncontingently prior to gambling.

Method

Participants

Twenty-six undergraduates enrolled at the University of Maryland, Baltimore County participated. Participants earned course credit for their participation in addition to potential monetary compensation (details in Procedure section below).

Apparatus

Software created using Microsoft Visual Basic was used to generate stimulus events on the screen of laptop personal computers and recorded responses automatically through the computer’s keyboard. Sessions were conducted in small rooms, with the laptop on a table and the participant seated in a chair facing the laptop.

Procedure

The experiment was conducted in a single session divided into two phases. In Phase 1, participants accrued tokens exchangeable for money (\$0.25 each) according to one of two conditions. In Phase 2, participants had the opportunity to gamble accrued tokens in a task similar to that described by Daugherty and Quay (1991).

Phase 1—Participants accrued tokens either by responding correctly to a conditional discrimination task (Contingent Delivery group) or in the absence of a response requirement (Noncontingent Delivery group). Phase 1 ended when participants accrued 20 tokens. Token delivery for each participant in the Noncontingent Delivery (NCD) group was yoked to a participant from the Contingent Delivery (CD) group (described below). Participants were assigned to groups using the following criteria in order to accommodate the yoking

procedure: 1) if the number of participants in each group was equal (including 0), the next participant was assigned to the CD group, 2) if the number of participants in the CD group exceeded the number in the NCD group, the next participant was randomly assigned to either group. A total of 13 participants were assigned to each group in this manner.

Contingent Delivery (CD) Group—Once a participant was seated in front of the laptop, the following instructions were provided on the screen:

“You are going to see a long list of 4-letter nonsense words. You will be able to see the list for 20 seconds. Within that 20 seconds, you need to press 'Q' on the keyboard if you see the 4-letter nonsense word 'PTLE' 3 or more times in the list. If 'PTLE' occurs less than 3 times in the list, then you need to press 'P' on the keyboard. If you are correct (you hit 'Q' and 'PTLE' occurred 3 or more times in the list, or you hit 'P' and it occurred less than 3 times) then you will earn one token. If you are incorrect, you will lose one token if you have a token to lose. The game then will start over with another chance to earn a token. Remember that you only have 20 seconds! This part of the game will continue until you have 20 tokens.”

The participant then clicked on a button to begin Phase 1. On the next screen, the following redundant instructions were located at the top of the screen, and were present throughout the phase:

“Do you see PTLE 3 or more times in the list? If so, press ‘Q’

Do you see PTLE less than 3 times in the list? If so, press ‘P’

You have 20 seconds from the time the array appears!”

At the bottom of the screen the participant was prompted to press the spacebar to begin a trial. Once the spacebar was pressed, the words “Ready,” “Set,” and “Go!” were presented in the middle of the screen. A matrix of 140 random 4-letter sequences comprised of the letters B, C, E, I, L, P, R, T, U, and Y were displayed. The letters in each sequence were selected with replacement from this list of possible letters. The 140 sequences were displayed in 7 columns, with 20 sequences in each column. A 20-s timer was initiated with the onset of the array. Across trials, the probabilities of the array containing either three or more of the sequence ‘PTLE’ or fewer than three of that sequence were both 0.5. If the array contained three or more of the specified sequence, pressing Q on the keyboard produced a token; if it contained fewer than three, pressing P produced a token. Pressing the incorrect key or failing to respond within 20 s resulted in the removal of a token to a minimum of 0. This was done to discourage responding arbitrarily. Feedback was given each trial with respect to the location(s) of the ‘PTLE’ sequence in the array, whether a token was earned or lost, and the total number of tokens accrued.

Noncontingent Delivery (NCD) Group—To provide a comparison for the effects of contingent token delivery, participants in the NCD group were provided tokens in a noncontingent manner. In Phase 1, token delivery for each participant in the NCD group was yoked to the temporal distribution of gains from a participant in the CD group. That is, for the NCD participant, tokens were delivered at the time in Phase 1 at which the CD participant gained a token until the NCD participant accrued 20 tokens and was not yoked to

the total duration of Phase 1 for the CD participant. As such, participants in the NCD group only experienced increases in accrued tokens during Phase 1 and the duration of the phase tended to be shorter than their CD counterpart.

Once a participant was seated in front of the laptop, the following instructions were provided on the screen:

“You are going to see lists of 4-letter nonsense words. There will be no need for you to respond in any way until your stack reaches 20 tokens, so just sit back and relax until your total reaches 20, then you will receive further instructions.”

The participant then clicked on a button to begin Phase 1. On the next screen, the following redundant instructions were located at the top of the screen, and were present throughout the phase: “Relax and watch your tokens get to 20. Then your game will start!”. No response options were available during this phase. Rather than experiencing trials, a matrix similar to that described above was displayed; however, the array differed in that the letters continuously changed throughout the duration of Phase 1. Also, the number of accrued tokens was continuously displayed below the array, similar to the feedback provided to the CD group at the end of each trial (“You now have X tokens”).

Phase 2

The effects of token accrual conditions in Phase 1 were examined with respect to responding in Phase 2. All participants experienced the same procedures in this phase. The onset of Phase 2 began with the following instructions displayed.

“Great – you just earned 20 tokens, each worth \$0.25. Now, you will have the opportunity to earn more tokens in a very simple game of chance, during which you can opt out at any time. When you want to cash out, follow the instructions on the next screen, and you will be finished. If you want to take chances to win more tokens, then follow the instructions on the next screen. There is a chance that you may lose some of your tokens in the next game, but you will have the option to cash out at any time, as well as the option to continue to try to win more tokens. It is completely up to you, so you can do what you want.”

On the next screen, accrued tokens were individually displayed, along with an image of a treasure chest and the following instructions, “You can now receive more tokens by opening the chest. Each time that you open it, there is a chance to GAIN or LOSE a token.” On each trial, participants were presented two response options: pressing ‘D’ to open the chest (gamble) or pressing ‘K’ to end the experiment and exchange tokens for money. If the participant pressed ‘D’, a token then was added to or subtracted from the participant’s total with the feedback “You have GAINED (or LOST) a token!”. The proportion of losses within blocks of 10 trials increased arithmetically as the phase progressed. In the first block of 10 trials, one loss occurred in one of the ten trials, and the trial number corresponding to this loss was determined randomly. In the second block, two losses occurred in randomly determined trials within the block, and so on, for 12 blocks. A summary of the ratio of gains to losses within each block is presented in Table 1. Participants were not informed about the probabilities of wins or losses at any time. If the participant pressed ‘K’ during a trial or gambled all 120 trials, a screen was then displayed indicating the number of tokens earned,

the monetary equivalent, and that the session was finished. The experimenter then dispensed the corresponding amount to the participant, concluding the session.

Results

For the CD group, the mean number of trials and duration of Phase 1 were 44 ($SD = 23.9$) and 950.2 s ($SD = 234.8$), respectively. The mean number of errors by CD participants during Phase 1 was 13.2 ($SD = 13.5$), with all CD participants making five or more errors. For the NCD group, mean duration of Phase 1 was 784.5 s ($SD = 317.6$).

Figure 1 depicts mean trials gambled in Phase 2 and net tokens for each group. Participants in the CD group gambled a mean of 46.1 trials ($SD = 42.8$) and ended the experiment with a mean of 25.6 net tokens ($SD = 13.6$). Participants in the NCD group gambled a mean of 93.2 trials ($SD = 19.7$) and ended the experiment with a mean of 17.8 net tokens ($SD = 13.5$). Paired t tests revealed a significant difference between groups in the number of trials gambled, $t(12) = -3.33$, $p < .01$, but not in the number of net tokens, $t(12) = 1.34$, $p = .20$. The lack of a significant difference in net tokens between the groups is due, in part, to the fact that the same token amount could be obtained at two distinct times during Phase 2 (e.g., net tokens after Trial 10 and Trial 80 were both 28). This nonlinear relation can be seen in Figure 2, which depicts net tokens as a function of trials gambled in Phase 2 for each participant.

In Trials 51–60 (Block 6), the proportion of trials with losses surpassed those with gains, constituting the point of diminishing returns (PDR) for gambling. The majority of CD participants (9 of 13) cashed out prior to the end of this trial block (Trial 60), whereas all NCD participants continued gambling beyond this point. Fisher's exact test indicated that this distribution of participants cashing out before and after the PDR was significantly different from chance ($p < .001$).

In Trials 91–100 (Block 10), gambling resulted in less than 20 net tokens, which was below the amount at the start of Phase 2. The majority of both CD and NCD participants (11 and 8, respectively) cashed out prior to this block. Fisher's exact test indicated that this distribution of participants cashing out with fewer than 20 tokens was not significantly different from chance ($p > .05$).

Additionally, we conducted correlational analyses to examine the relation between costs incurred while accumulating tokens during Phase 1, in terms of total trials and duration in the phase, and token value, in terms of net tokens. Figure 3 (top panel) depicts a scatterplot of the relation between the number of trials in Phase 1 and the number of tokens at the end of Phase 2 for the CD group. A Spearman's rank order test showed a strong, positive correlation between Phase 1 trials and net tokens, which was statistically significant, $r_s(11) = .75$, $p = .003$. An identical analysis could not be conducted with the NCD group, as Phase 1 token delivery for NCD group participants was time-based rather than response-based. However, the number of trials completed in Phase 1 by CD participants showed a strong, positive correlation with the duration of Phase 1, $r_s(11) = .95$, $p < .0001$. Therefore, to examine cost with respect to time spent accumulating tokens, we examined the relation

between Phase 1 duration and net tokens for each group (Figure 3, bottom two panels). For the CD group, there was a strong, positive correlation between Phase 1 duration and net tokens, $r_s(11) = .78$, $p = .0016$. For the NCD group, these variables were not significantly correlated, $r_s(11) = .21$, $p = .48$.

Discussion

This study compared persistence of gambling on a task with increasing probabilities of loss for participants who, prior to gambling, either earned tokens contingent on performance or were provided tokens noncontingently. Results showed that participants who received free tokens gambled more trials than those who earned them. Although participants in the CD group exited the experiment with a greater number of tokens on average, no statistical difference was observed between groups for net tokens.

Statistical analysis of the distribution of when participants stopped gambling with respect to the PDR showed that CD participants generally cashed out prior to or upon experiencing diminished returns, whereas NCD participants did not. Interestingly, more than one third of the CD participants (5 of 13) cashed out before the end of the first block, when the probability of wins was greatest and the probability of losses lowest. These data suggest a strong aversion to either the actual loss of tokens or even the prospect of potential losses (signaled by the Phase 2 instructions), as two participants cashed out prior to experiencing any loss. Of the eight CD participants that continued gambling beyond the first block, half cashed out at or before the PDR. These results suggest that, relative to NCD participants, those who worked for the tokens (and thereby exerted effort) prior to gambling displayed greater sensitivity to loss. By extension, these data suggest that the subjective value of tokens was greater for CD participants, despite the fact that the absolute exchange value (\$0.25) per token was identical across groups.

In addition to the effects observed as a function of contingency, we also found evidence of the relation between effort and value through correlational analyses of events from Phases 1 and 2 of the experiment. Higher costs incurred during token accumulation, in terms of either amount of trials or time during Phase 1, were associated with more net tokens at the conclusion of the study among CD participants. Conversely, there was no relation between Phase 1 duration and net tokens among NCD participants despite time elapsing during token accrual. As such, it appears that contingency may be important in determining whether an event (expended effort, elapsed time) functions as a cost during the acquisition of reinforcers and thereby influences future stimulus value.

The present results are consistent with previous studies that demonstrated enhanced value of stimuli through establishing histories of either contingent delivery (e.g., DeLeon et al., 2005) or greater effort (e.g., Clement et al., 2000). With respect to the effects of prior effort, the procedures used by Brandt et al. (2013), Speelman and Dixon (2014), and this study all provide evidence that these effects are not limited to the specific learning histories typically programmed in studies of WTC in which the organism experiences multiple levels of effort during training. As such, the clear outcomes observed when using a between-groups design may implicate a procedural issue that has contributed to the mixed findings reported when

using within-subject designs. That is, failure to find the value-enhancing effects of prior effort (e.g., Vasconcelos et al., 2007) may be due to a failure to mitigate carryover effects between differing levels of effort, which are obviated by between-group designs. Researchers studying WTC might consider using preparations in which subjects experience only one level of effort and subsequently assess stimulus value under single-operant arrangements.

Although our findings are concordant with previous research, several limitations of the study warrant attention. First, participants only experienced the progression once. However, the results of Brandt et al. (2013) suggest that repeated exposure to some gambling scenarios may not be feasible for examining value manipulations based on historical conditions. This seems especially true of the experimental preparation used here, in that participants would be unlikely to continue gambling beyond the PDR with repeated exposure to Phase 2.

Additionally, the number of trials in Phase 1 was unconstrained, allowing differences in both trials and time in Phase 1 to occur. Although this revealed an interesting relationship between the events of Phase 1 and net tokens in Phase 2, no causal relation was established. It may be the case that responding in both Phases 1 and 2 was a function of individual differences in more global behavioral tendencies, such as those the preparation has typically been used to investigate (e.g., “impulsiveness”), rather than the experimental histories programmed by the procedures. Future experiments could address this issue by measuring responding on an alternative assessment related to the experimental tasks (e.g., delay discounting, gambling questionnaires) to allow for examination of moderating variables. Alternatively, by including an additional group with a more effortful schedule during Phase 1 (similar to Speelman and Dixon, 2014), researchers could examine whether parametric differences would be observed between groups, which could provide more convincing evidence that obtained results were due to the experimental history rather than individual differences.

Lastly, the yoking procedure may not have served as an adequate control. Participants in the NCD group did not experience token loss during Phase 1, resulting in a generally shorter duration of Phase 1 relative to their yoked counterparts (mean difference = 165.7 s); however, a paired *t* test did not yield a statistically significant difference. Future investigations should specifically examine whether loss contingencies during token accrual affects stimulus value.

As support for the value-enhancing effects of both contingent delivery and prior effort grows, exploring practical implications may prove beneficial. There are myriad situations in which altering the value of a stimulus could promote socially important outcomes. For instance, increasing the value of healthy food, conditioned reinforcers in educational settings (e.g., grades), or other desirable outcomes conceivably could occur through this process. As a more specific example, behavioral interventions in which a reinforcer can be removed (e.g., a classroom token economy that includes response cost) may lead to greater behavior change if the reinforcer is initially acquired contingently. Research directly evaluating these potential applications, as well as the limits of the effect, are certainly warranted.

In conclusion, the present findings are consistent with results of previous research demonstrating the value-enhancing effects of contingent delivery and provide additional evidence of a positive relation between prior effort and subsequent value. Participants persisted in gambling under conditions of diminishing returns to a lesser extent when they earned tokens than when they were provided tokens for free. Additionally, both time and effort required to obtain tokens prior to gambling (i.e., costs) were positively correlated with net tokens among participants who earned tokens but not among those who received tokens noncontingently, suggesting that contingency may be an important determinant of value.

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Figure 1. Number of trials gambled (left panel) and net tokens (right panel) for contingent delivery (CD) and noncontingent delivery (NCD) participants in Phase 2. Each circle represents a value for one participant; the bars represent the group mean.

Figure 2.

Net tokens as a function of trials gambled when participants exited Phase 2. Closed circles and open squares depict data for contingent delivery (CD) and noncontingent delivery (NCD) participants, respectively. Dashed gray lines depict the minimum and maximum tokens possible within each block. The hashed gray area depicts the trial block in which participants contacted diminishing returns for continued gambling.

Figure 3. Scatterplots of net tokens in Phase 2 and trials (top panel) or duration (middle and bottom panels) in Phase 1.

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Table 1

Ratio of gains to losses across 10-trial blocks in Phase 2

Block	Trials	Gains	Losses	Net	Total
--	0				20
1	1-10	9	1	8	28
2	11-20	8	2	6	34
3	21-30	7	3	4	38
4	31-40	6	4	2	40
5	41-50	5	5	0	40
6	51-60	4	6	-2	38
7	61-70	3	7	-4	34
8	71-80	2	8	-6	28
9	81-90	1	9	-8	20
10	91-100	0	10	-10	10
11	101-110	0	10	-10	0
12	111-120	0	10	-10	0