# Reward Type Predicts Temporal Discounting in Rats: A Pilot Study

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## Background

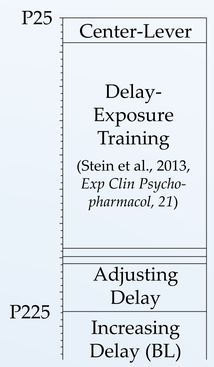
People who steeply discount the future suffer higher incidence of psychiatric disorder, obesity, debt, and dependence on nearly all drugs of abuse. Thus, interest in *temporal discounting* has propagated across psychology, neuroscience, and economics. To study this trans-disease process, psychologists and neuroscientists commonly employ animal models, which enable manipulations that would be impractical or unethical in humans. The tradeoff is that animal models are imperfect.

In particular, humans evince a *magnitude effect*—they discount small rewards more steeply than large rewards. Researchers have struggled to replicate this bias in pigeons and rodents. Calvert, Green, & Myerson (2010; *J Exp Anal Behav, 93*) hypothesized that an allomorphic assay (e.g., grain versus sucrose pellets) might prove more sensitive to the magnitude effect than the more common isomorphic assay (e.g., 1 versus 3 grain-based pellets). Instead, their negative findings reinforced common wisdom: In these model organisms, reward size does not affect discounting.

Therefore, in the first revisit of Calvert et al.'s hypothesis, positive findings were not to be expected.

## Methods

I measured temporal-discounting rates of five male Long-Evans rats. Subjects were not naïve (see Timeline). Rather, baseline for this pilot study consisted of the increasing-delay task (Evenden & Ryan, 1996; *Psychopharmacology, 128*) around post-natal day 225 (P225). I used grain pellets during baseline and indexed discounting with area-under-the-curve (AUC; Green et al., 2001; *J Exp Anal Behav, 76*).




*Timeline.* Sequence of events through baseline (BL).

Subjects were pre-exposed to pellet replacements in their home cages. Then, following stability, I replaced the grain pellets (Gr) with chocolate-grain pellets (ChGr) and/or chocolate-sucrose pellets (ChSu). Wherever changes in discounting between conditions were noted, I programmed reversals. Finally, I assessed relative preference for Gr and ChSu pellets with a "two-bottle" assay (Calvert et al., 2010) and a concurrent VI-VI assay (i.e., the matching law; Fleshler & Hoffman, 1962; *J Exp Anal Behav, 5*).

By comparison, Calvert et al. (2010) employed an adjusting-amount task (Richards et al., 2001; *J Exp Anal Behav, 71*) to test five male Sprague-Dawley rats (P120; naïve) across grain, sucrose/cellulose, and sucrose pellets.

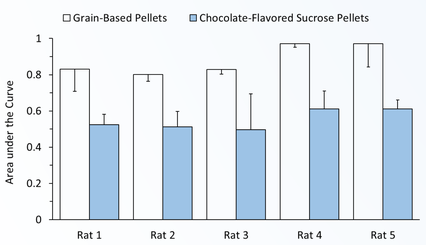
## Results

ChSu pellets consistently and substantially decreased AUC (i.e., increased impulsivity) relative to Gr pellets (see Bar Graph).

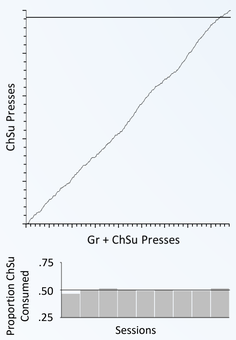
Three trends emerge following introduction of ChSu pellets (see Time-Series Graphs). First, Rats 2, 3, and 5 showed reversible increases in impulsivity. Second, Rat 1 showed an irreversible increase in impulsivity. Third, Rat 4 showed transitory increases in impulsivity.

By contrast, ChGr pellets had no discernable effect on basal discounting (see Time-Series Graphs, Rats 2 and 5).

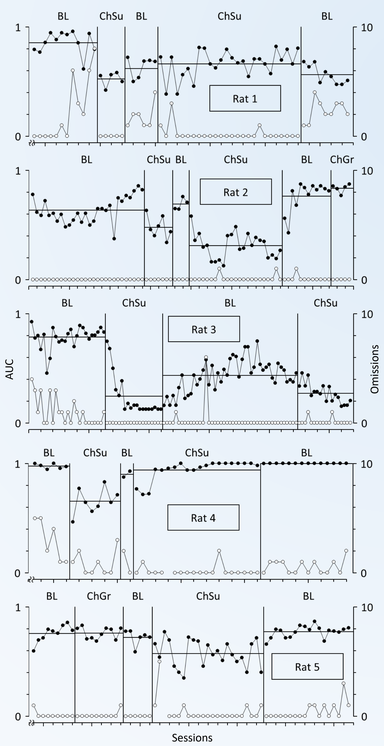
While omissions with ChSu tended to be lower than with Gr—suggesting preference for ChSu pellets—neither preference assessment offered either convergent or divergent evidence (see Preference Assessments for representative data).




*Bar graph.* Mean AUCs for five sessions before and after introduction of ChSu pellets. Error bars denote standard deviations.




*Preference assessments.* Matching (top) and "two-bottle" (bottom) data from Rat 2.




*Time-series graphs.* AUC (closed markers) and omissions (open markers). Mean AUC denoted by horizontal lines.

## Discussion

Calvert et al. (2010) hypothesized that cross-species procedural variations might mask the magnitude effect in animal models. Thus, they pursued the magnitude effect with an allomorphic assay. Subsequent to their null findings, no one has carried on this charge. Why do so when all evidence points in one direction? I revisited Calvert et al.'s hypothesis for the very reason that temporal discounting is a procedurally diverse area of research. Implementing common but different procedures, I uncovered compelling evidence for sensitivity to reward magnitude in rats.

Perhaps two variables most readily account for my unorthodox findings. First, the magnitude effect is unlikely to manifest across all comparisons. Instead, we might expect greater contrast, for example, between commodities of substantially differing valence. It may be that Calvert et al. was unlucky in their selection of commodities. This possibility is supported by the finding that one of my variants, ChSu, systematically altered discounting rates relative to Gr, while another variant, ChGr, had no effect.

Second, the correlation between increasing-delay and adjusting-amount tasks is imperfect ($r = .71$, $p < .001$, Craig et al, 2014, *Behav Pharmacol, 25*; $r = .21$, $p = .46$, Peterson, Hill, & Kirkpatrick, 2015, *J Exp Anal Behav, 103*). An increasing-delay task, which fixes reward sizes, may be more sensitive to qualitative manipulations of rewards.

Regardless, these results do not buttress cross-species generality or model-organism validity. The magnitude effect appears inverted: The rats more steeply discounted the larger (i.e., more preferred) reward, not the smaller (i.e., less preferred) reward, assuming omissions accurately indexed preference.

Limitations include that the subjects were not experimentally naïve and unambiguous assessments of preference were lacking. Thus, a replication of these findings with naïve animals should be pursued.

*Collection of these data was made possible by the support of Gregory Madden's laboratory at Utah State University.*