Motivation and timing

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Reward value effects on peak procedure timing

- Roberts (1981) – pre-feeding resulted in a rightward shift in timing
- Blomeley, et al. (2004) – changing the concentration of condensed milk altered timing of the peak
- Ludvig et al. (2007) – decreasing electrical brain stimulation produced a rightward shift in timing
- Ludvig, Baldi, & Spetch (2011) – smaller rewards resulted in later start times

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Reward value effects on peak procedure timing

- Galtress & Kirkpatrick (2009)
  - Increasing reward magnitude shifted the peak to the left
  - Decreasing reward magnitude did not significantly change the peak location
  - Devaluation by LiCl shifted the peak to the right
  - Devaluation by pre-feeding shifted the peak to the right

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The Peak Procedure

Fixed Interval Trial

60 s

Lever inserted

Food is primed
If rat responds,
Food delivered
Lever retracted

Galtress & Kirkpatrick (2009)

Peak Trial

180 s

Lever inserted

Lever retracted

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Group 1-4-1 Results

Galtress & Kirkpatrick (2009)

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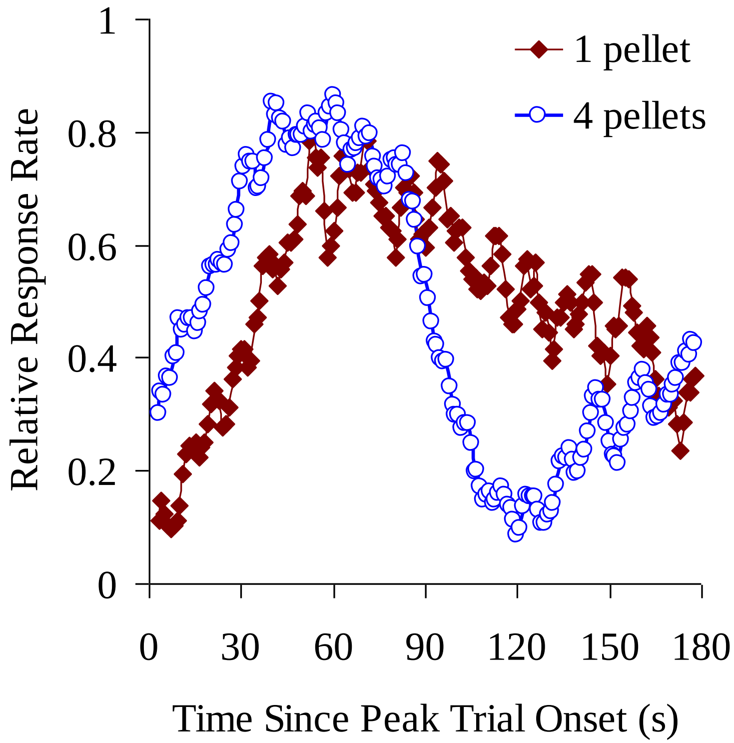
Group 1-4-1 Results



Galtress & Kirkpatrick (2009)

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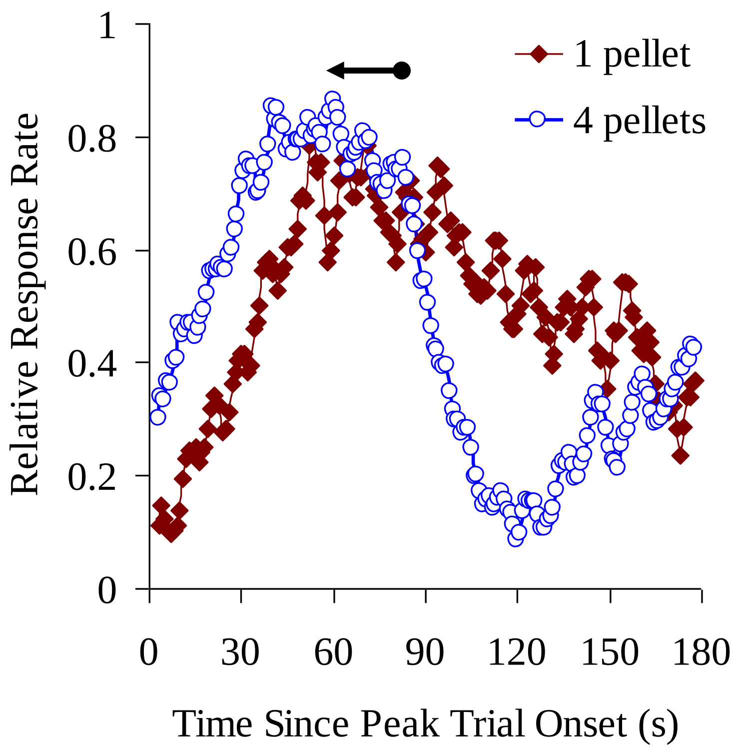

Galtress & Kirkpatrick (2009)

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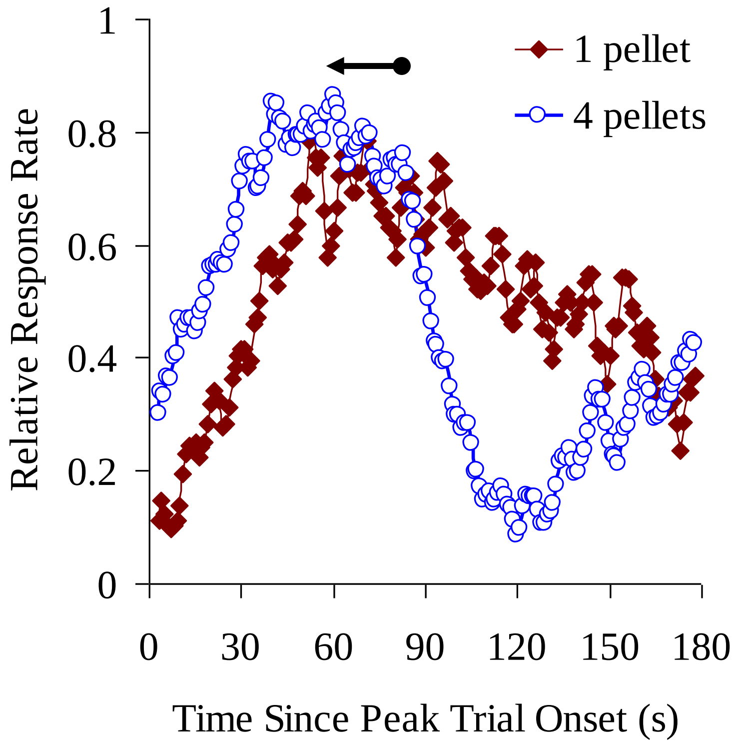

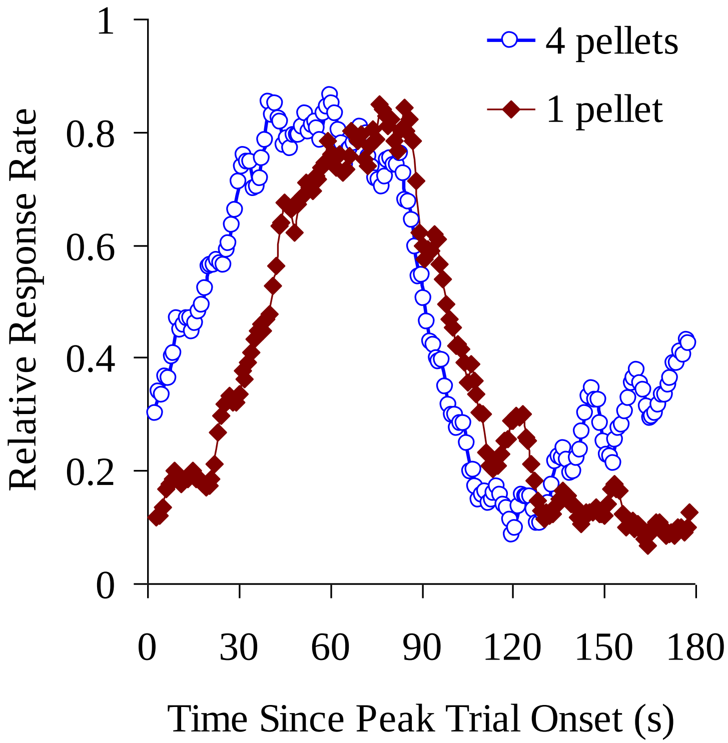

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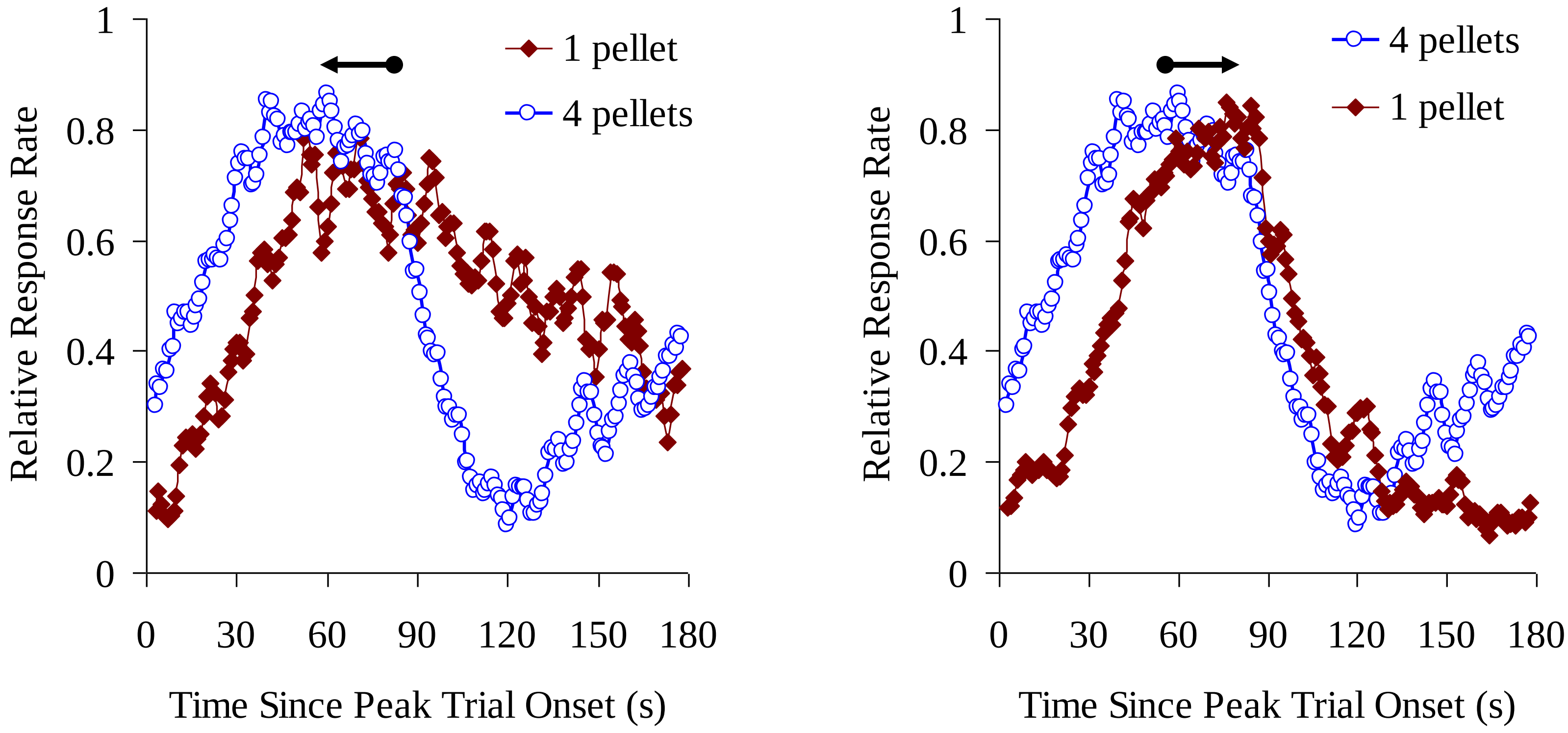

Galtress & Kirkpatrick (2009)

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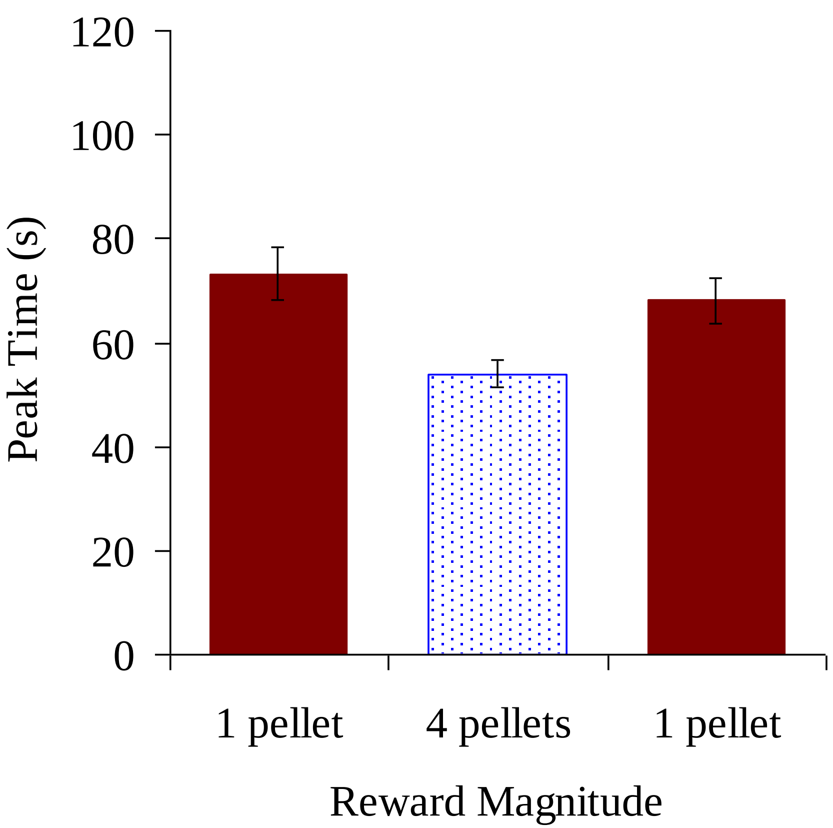

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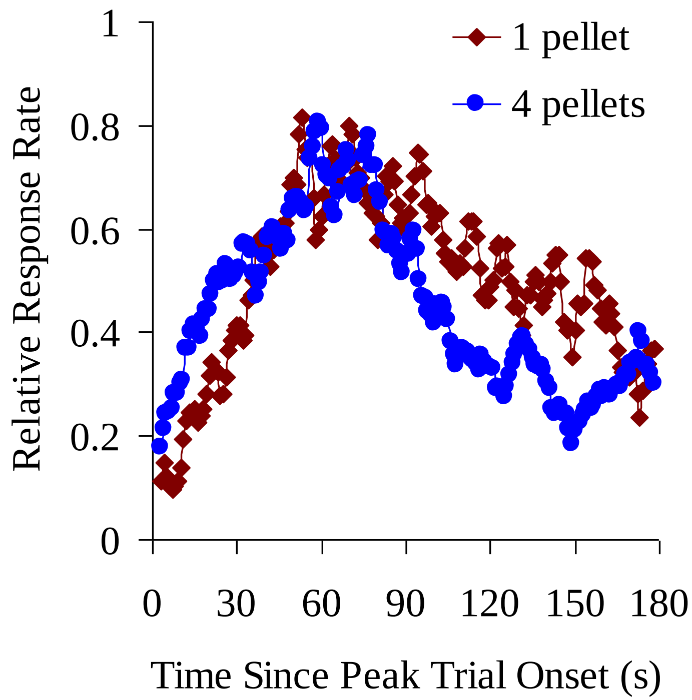
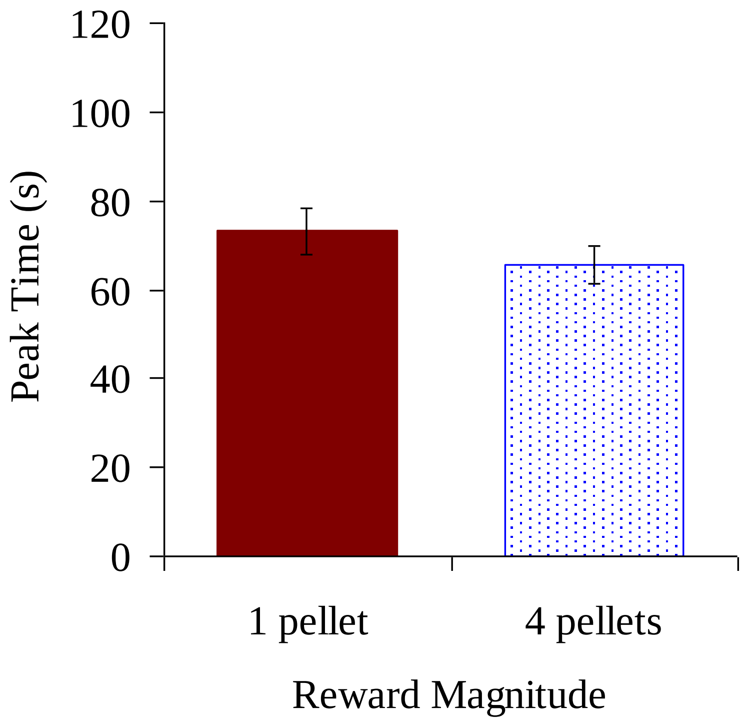
Comparison of Initial Baseline Conditions





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Devaluation by LiCl

10 g of pellets in home cages → LiCl injection
1 day recovery period

Peak Trial

180 s

Lever inserted

Lever retracted

Galtress & Kirkpatrick (in press)

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Devaluation by LiCl

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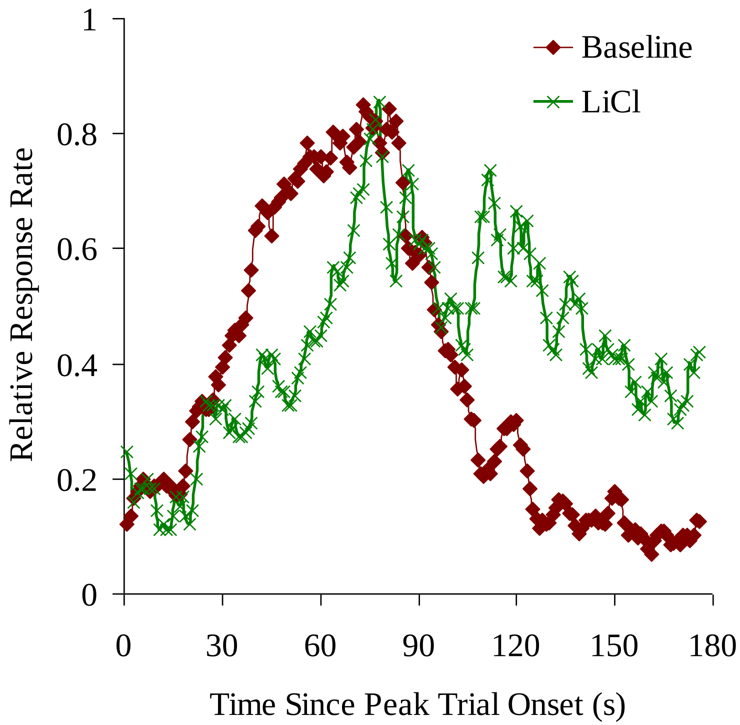
Devaluation by LiCl



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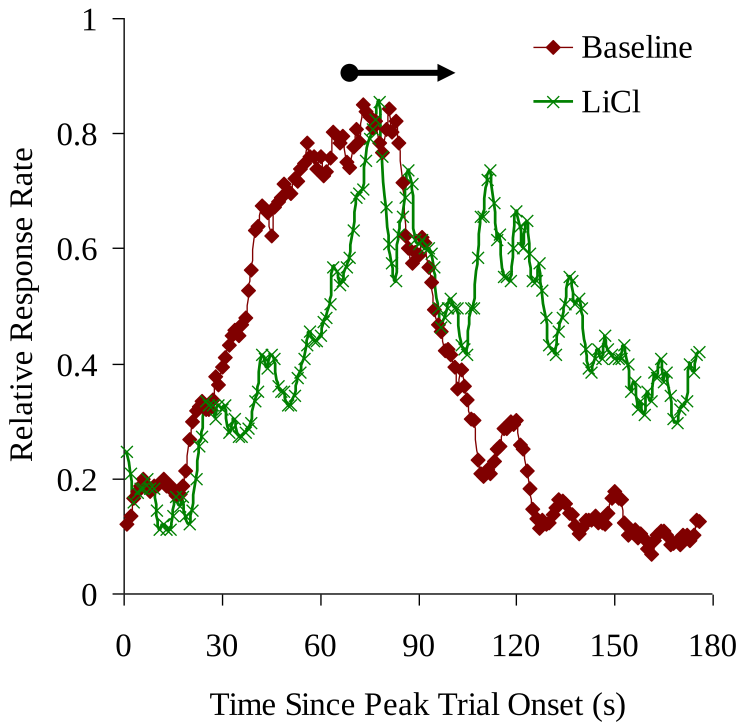
Devaluation by LiCl



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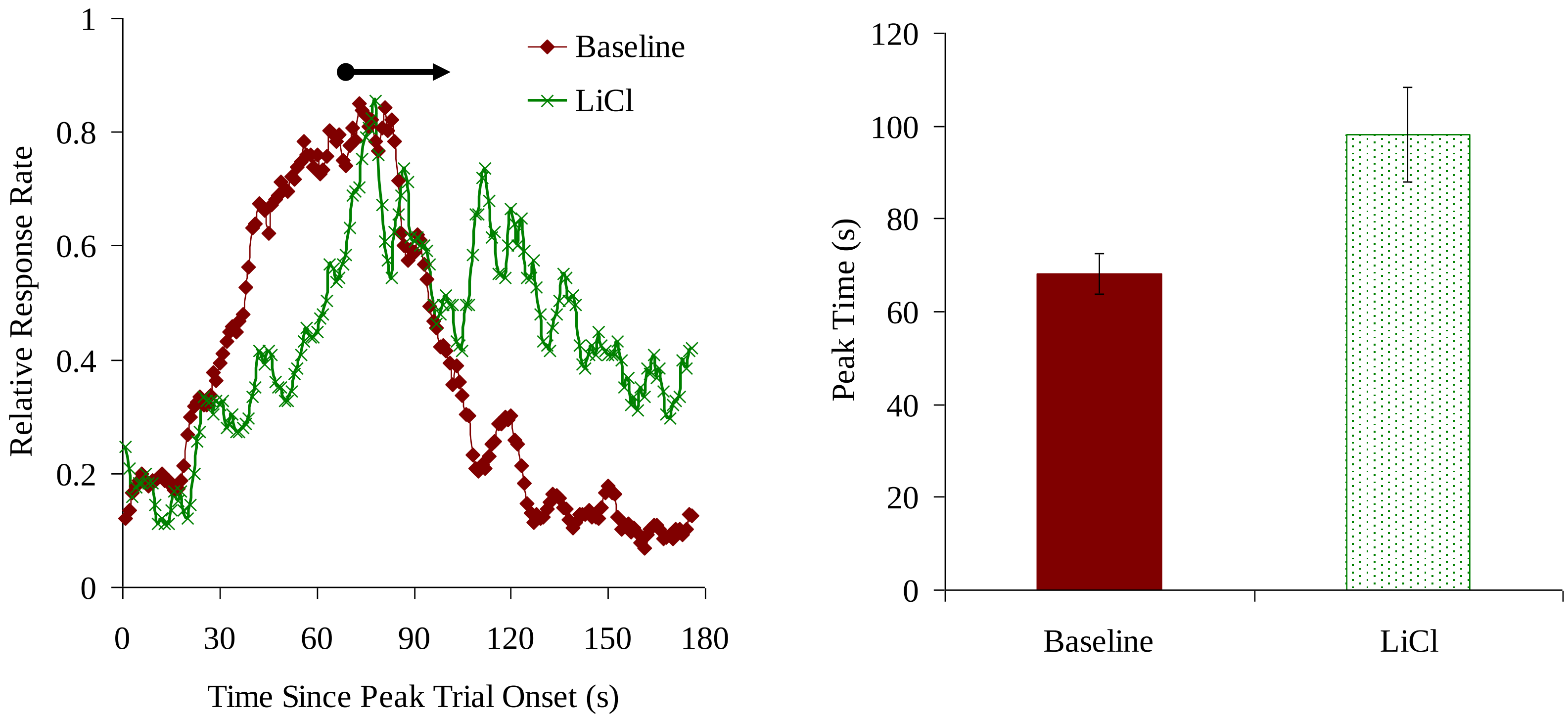
Devaluation by LiCl



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Devaluation by Pre-feeding

10 g of pellets in home cages / 30 min

Peak Trial

90 or 180 s

Lever inserted

Lever retracted

Galtress & Kirkpatrick (in press)

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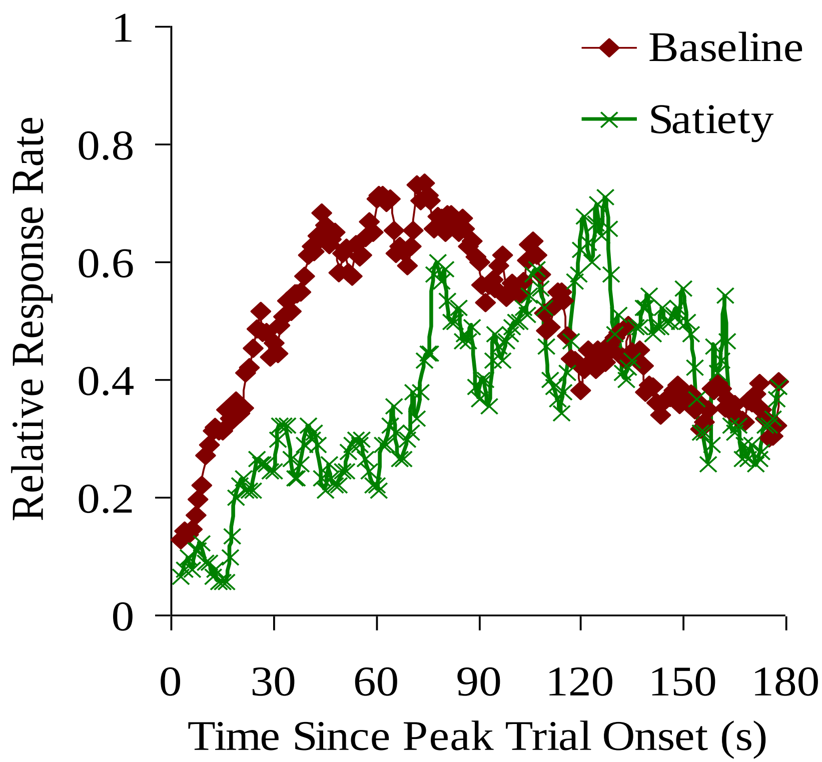
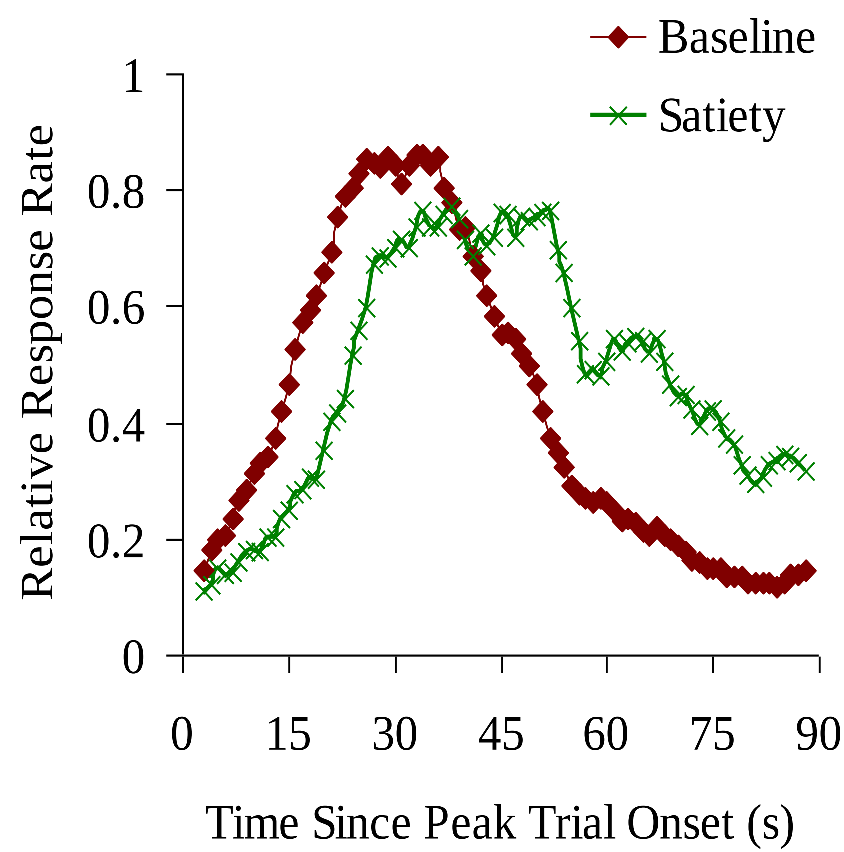
Devaluation by Pre-feeding





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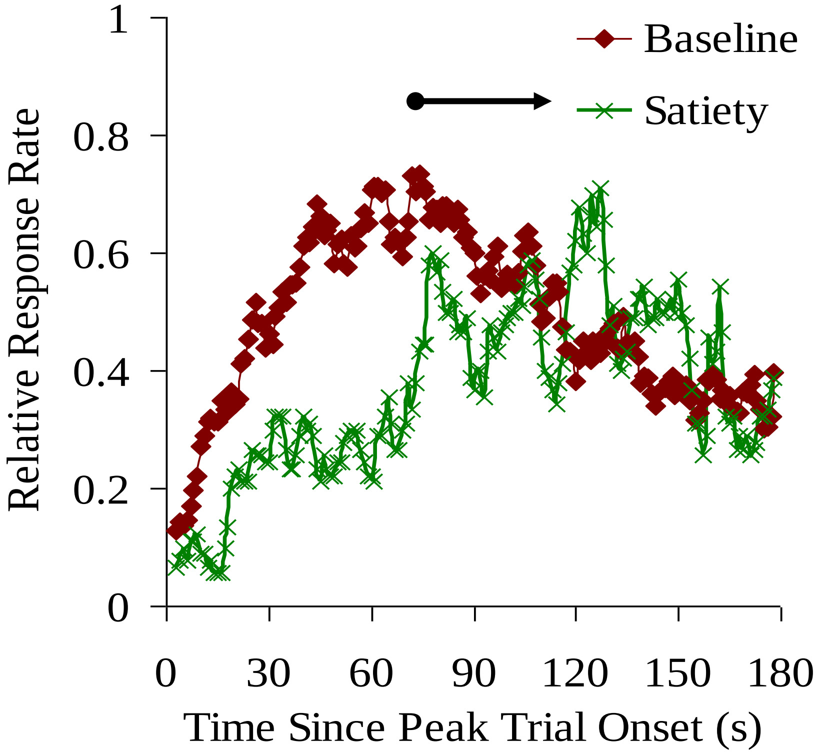
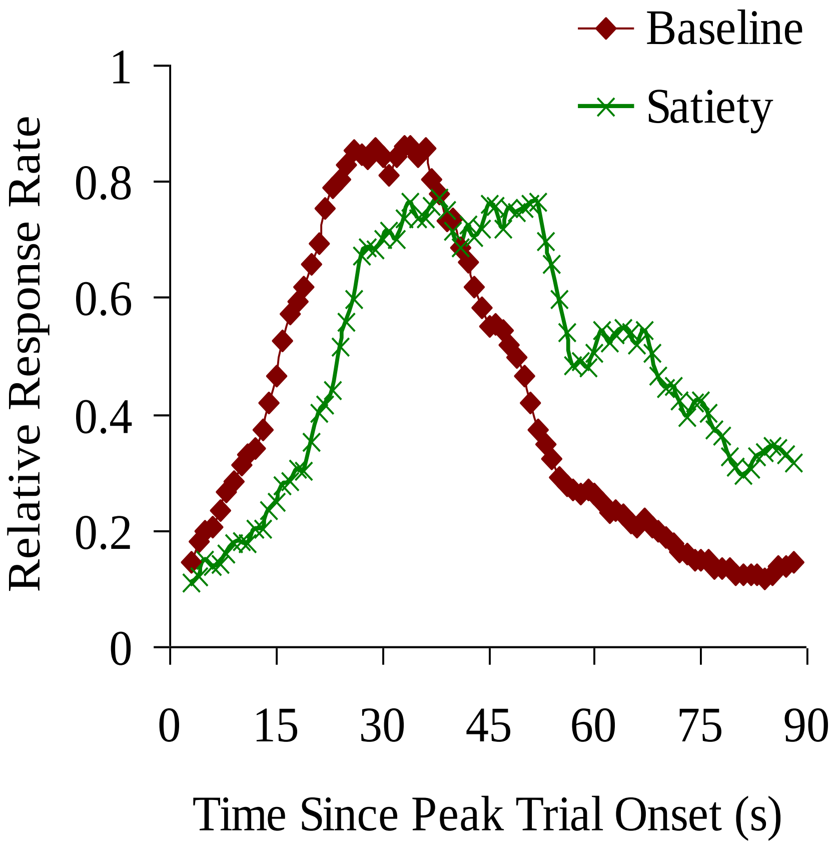
Devaluation by Pre-feeding





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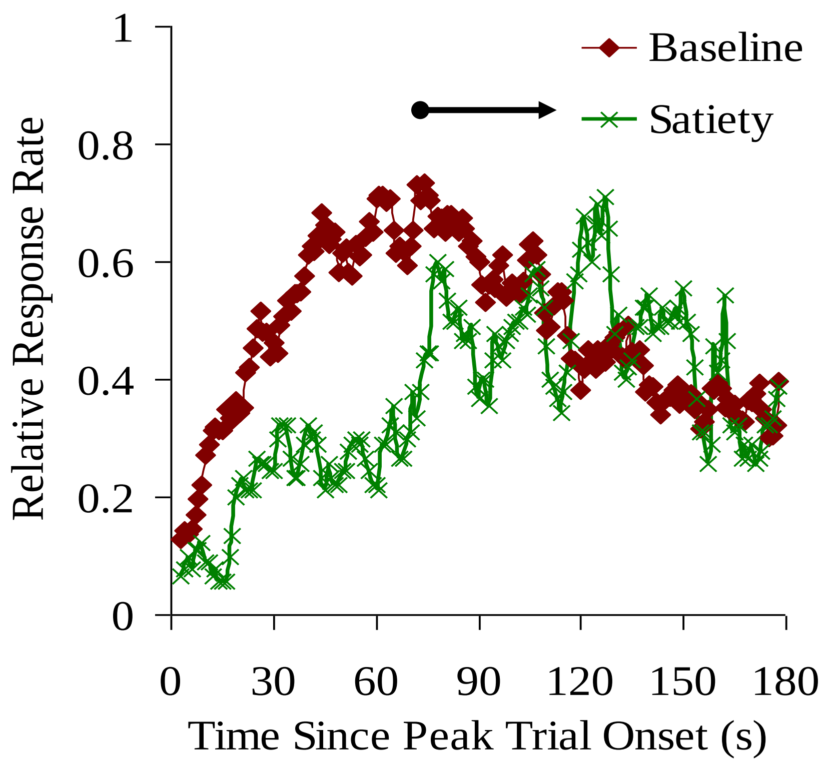
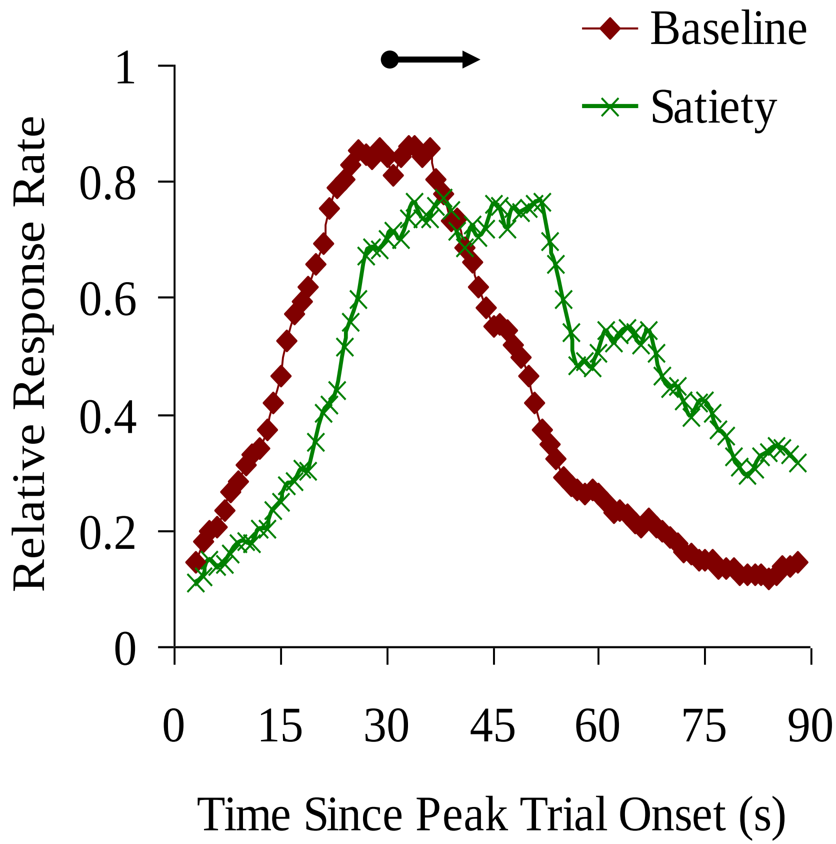
Devaluation by Pre-feeding





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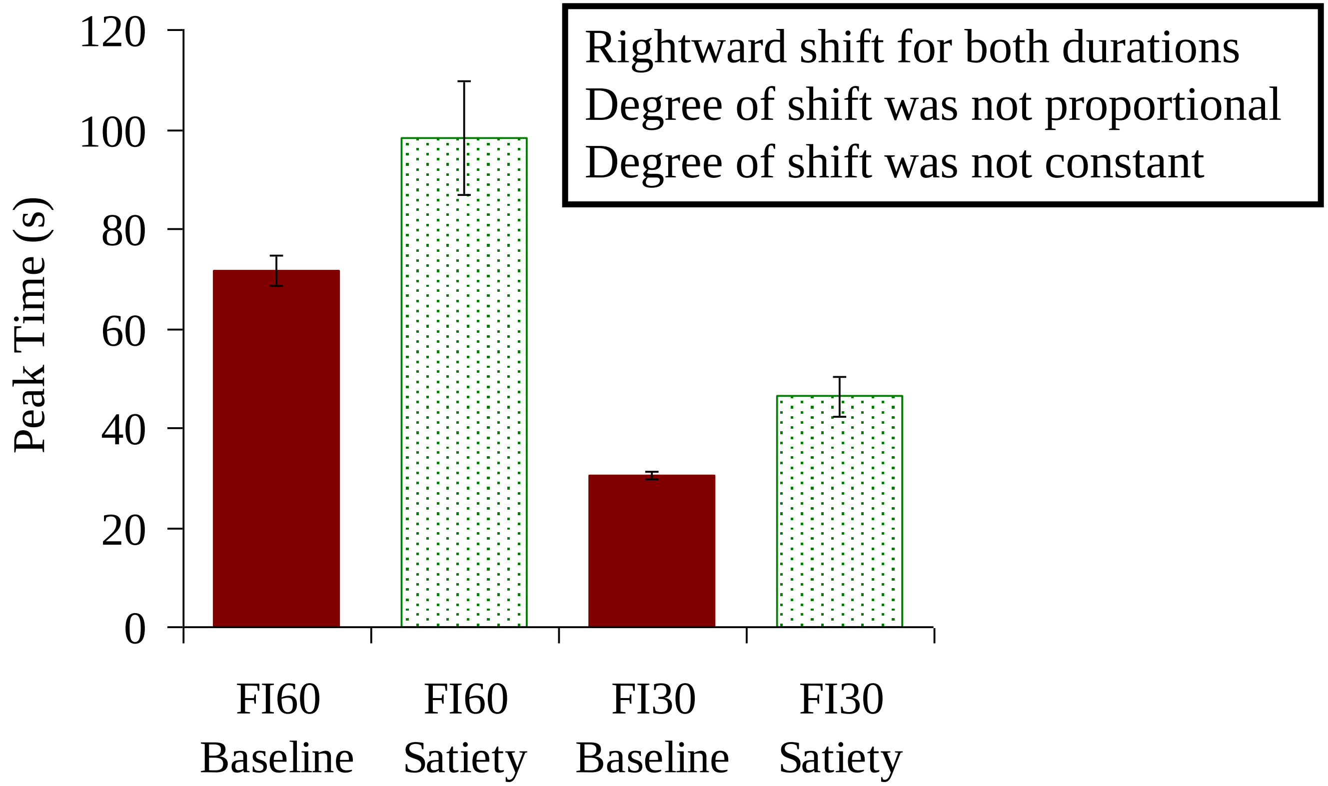
FI30 vs. FI60 Satiety Results



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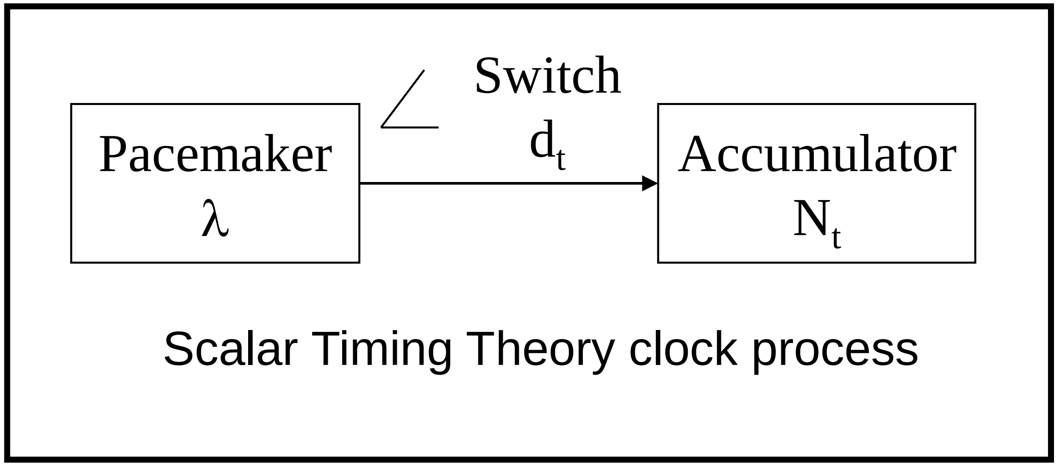
Possible mechanisms

- Reward value changes might change pacemaker speed
  - Predicts multiplicative (proportional) effects



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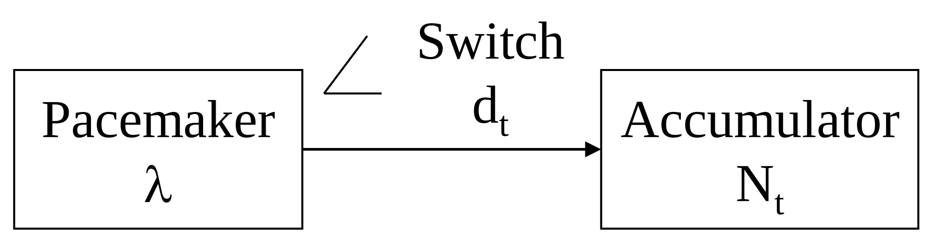
Possible mechanisms

- Reward value changes might alter attention
  - Delayed switch closure – additive effect
  - Switch fluctuations – changes in the rate of fluctuation would induce a multiplicative effect



Scalar Timing Theory clock process

Devaluation effects during training vs. testing

The effect of changes in motivational state on timing

Tiffany Galtress and Kimberly Kirkpatrick

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Introduction

A change in motivational state by pre-feeding rats prior to the start of a subsequent peak-interval (PI) test session produces a rightward shift in the observed response function compared to baseline (Roberts, 1981). Further investigation into this effect has suggested a possible role for attentional factors, as opposed to changes in clock speed (Galtress & Kirkpatrick, 2009). The current study examined this issue further by training and testing rats under different motivational conditions.

Method

Twenty-four rats were divided into two pre-feeding conditions:

Group	Baseline	Test
Non-Fed	No Pre-feed	Pre-fed
Pre-fed	Pre-fed	No Pre-feed

The rats were trained on a baseline phase peak interval (PI) procedure where either the insertion of a lever or the onset of a light (levers remained inserted at all times) was the cue to the start of a 60-s fixed interval. After this time the first response on the lever resulted in either light offset or lever withdrawal and the delivery of a food pellet. Intermixed with these were non-reinforced PI trials where the lever remained inserted or the light remained on for 240 s and lever presses were recorded.

A single test session followed the baseline phase in which the rats received the 240-s PI trials only to assess the rats response patterns without any reinstatement of the fixed interval duration. This allowed for the measurement of the effect the change in motivational state through the switch in pre-feeding condition had on the rats ability to time a previously learned duration.

Contact: Tiffany Galtress – galt@ksu.edu ;
Kimberly Kirkpatrick – kirkpatr@ksu.edu

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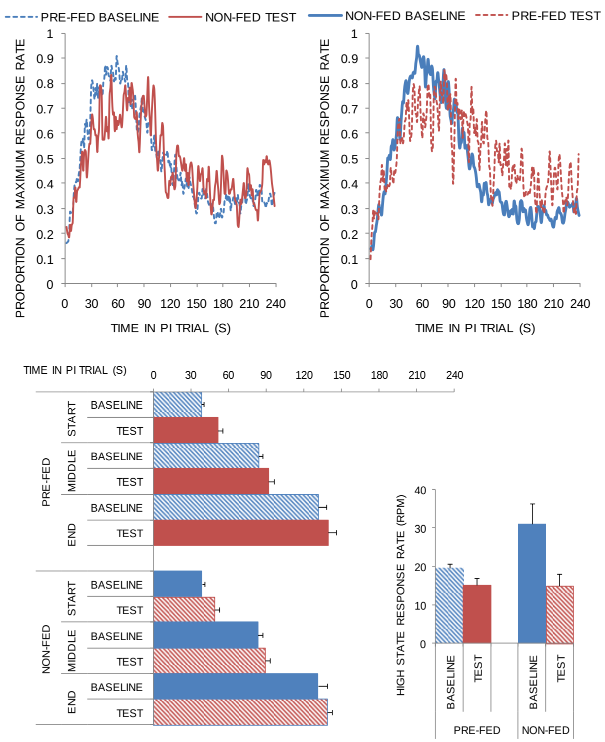

Top panels depict the PI response functions on baseline and test for both Group Pre-fed and Group Non-fed. The lower panel shows the results of the single trials analysis for both groups. / bars denote pre-feeding prior to an experimental session.

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Results

Both groups showed a rightward shift in the response function between baseline and test, supported by the later start, middle and to some extent end times of the high response state.

Satiety through pre-feeding is evident in the lower high state response rate for Group Pre-fed compared to Group Non-fed during the baseline phase. The overall high state response rate was also greater during the baseline phase than test, a usual effect of testing in extinction. The greater reduction in response rate between baseline and test for Group Non-fed compared to Group Pre-fed is again evidence of satiety through pre-feeding.

Conclusions

Satiety through pre-feeding prior to a test session has been shown to produce a rightward shift in the PI response function. A decrease in clock speed or a lack of attention to time have been suggested as possible mechanisms.

The present experiment replicated this effect and also investigated the reverse manipulation, where the pre-feeding was given during training and removed on test. The resultant increase in clock speed should produce a leftward shift in the response function in the Pre-fed group during the test phase, however, a rightward shift similar to the original pre-feeding effect was found. This is suggestive that any change in motivational state through the introduction or removal of pre-feeding affects the attention to the interval being timed.

Roberts, S. (1981) Isolation of an internal clock. Journal of Experimental Psychology, 7, 242-268.
Galtress, T. and Kirkpatrick, K. (2009) Reward value effects on timing in the peak procedure. Learning and Motivation, 40, 109-131.

Acknowledgement: Thanks to Macy Ip for her help in running the study.

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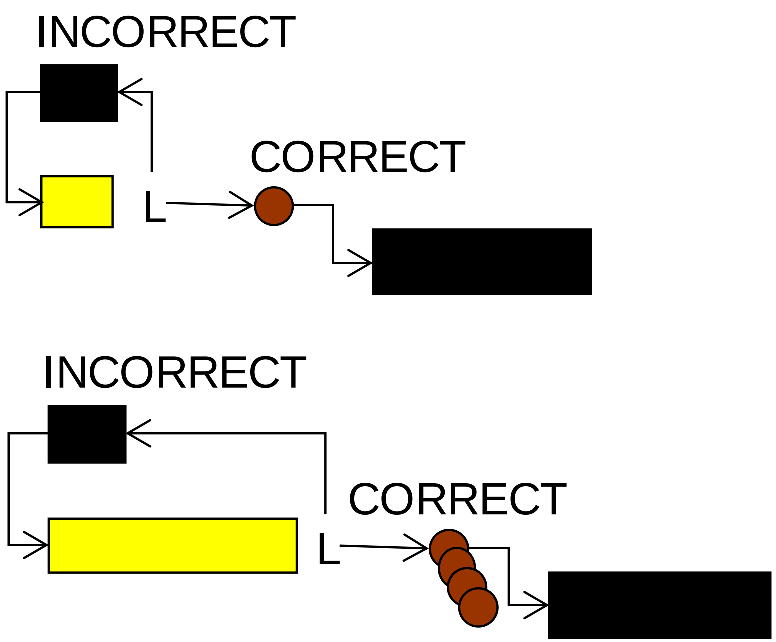
Reward magnitude and bisection



Galtress & Kirkpatrick (2010a)

- Rats trained to discriminate short (2 s) vs. long (8 s) signal
- Then, tested with intermediate durations
- Experiment 1: Reward on short or long trials was increased from 1 to 4 pellets
- Experiment 2: Original training with 1 vs. 4 pellet rewards

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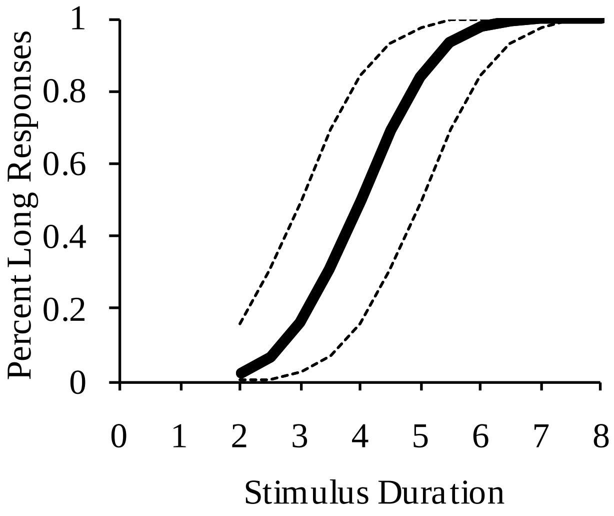
Clock speed



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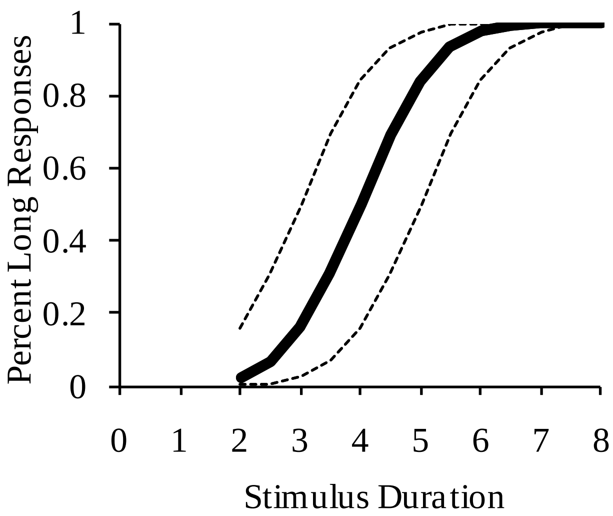
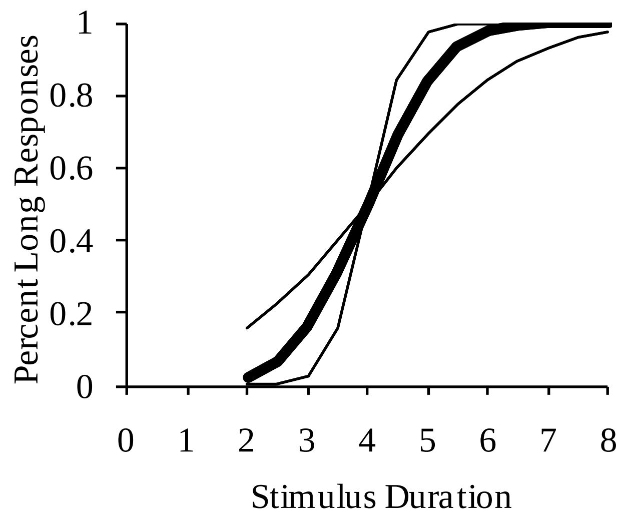
Clock speed



Attention



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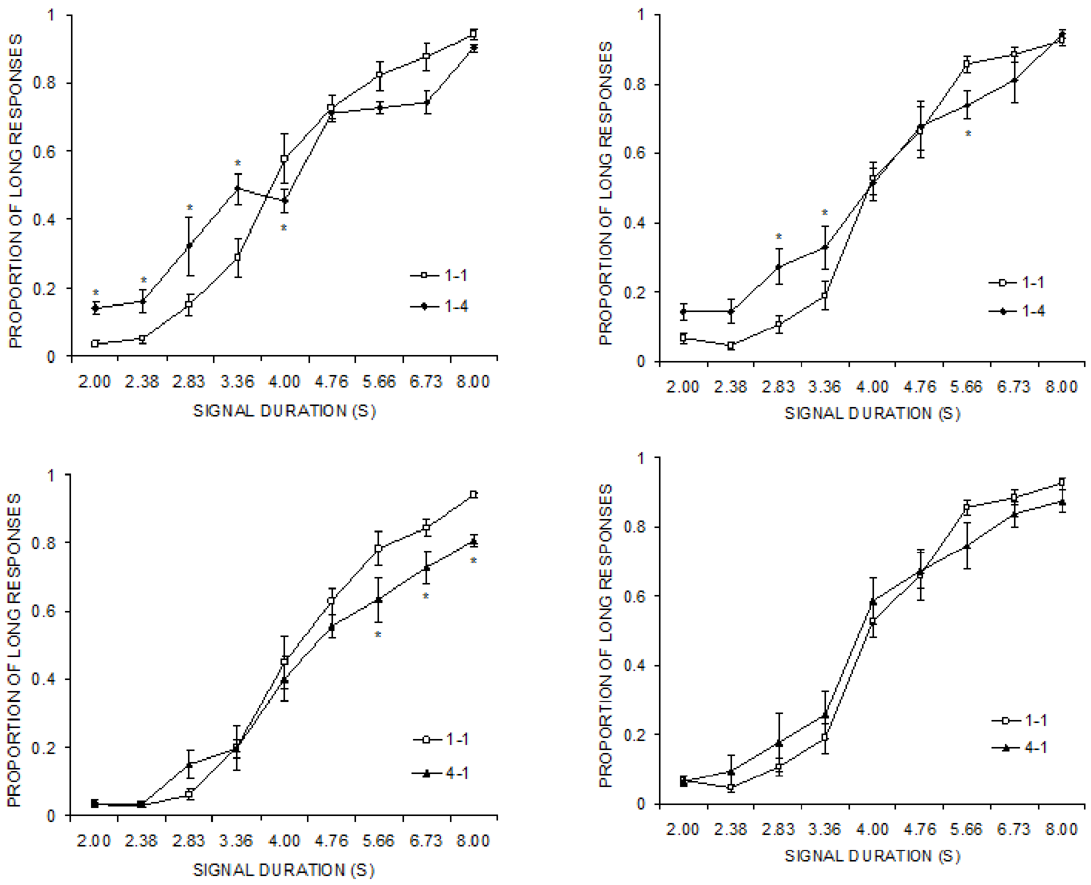
Reward magnitude and bisection



Galtress & Kirkpatrick (2010a); see also Ward & Odum (2006)

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Motivation and timing interactions

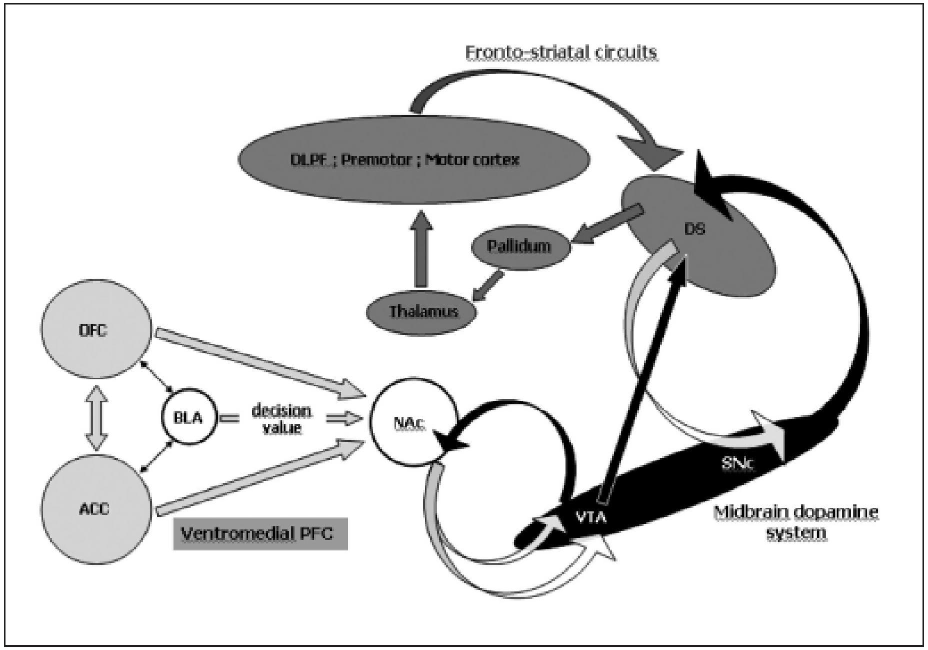

Figure. Proposed model of ventromedial PFC top-down influence on behavior generation. OFC, orbito-frontal cortex; ACC, anterior cingulate cortex; BLA, basolateral amygdala; NAc, nucleus accumbens core; VTA, ventral tegmental area; SNc, substantia nigra pars compacta; DS, dorsal striatum; DLPF, dorsolateral prefrontal.

Guimarães et al. (2008)

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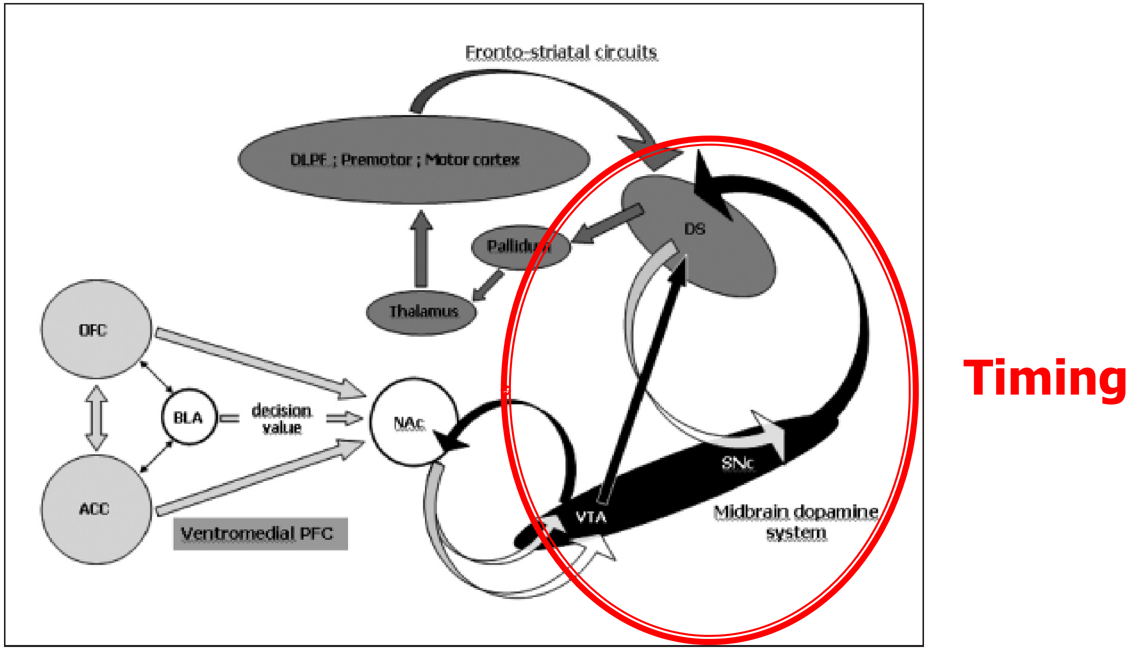
Motivation and timing interactions



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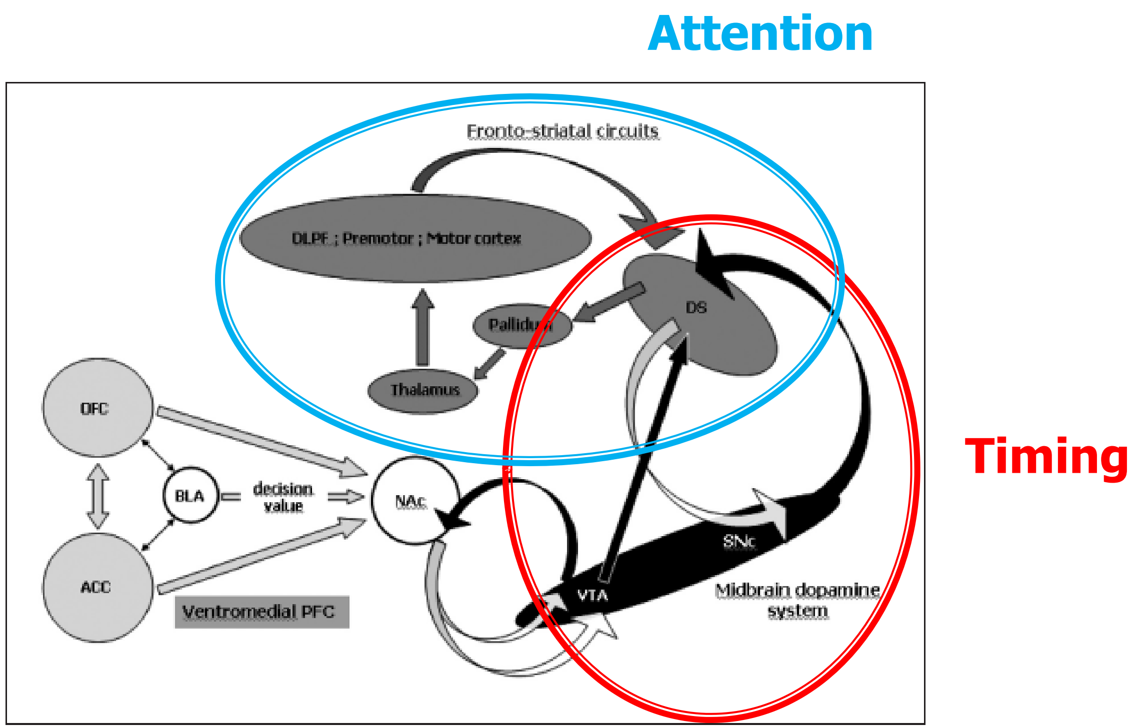
Motivation and timing interactions



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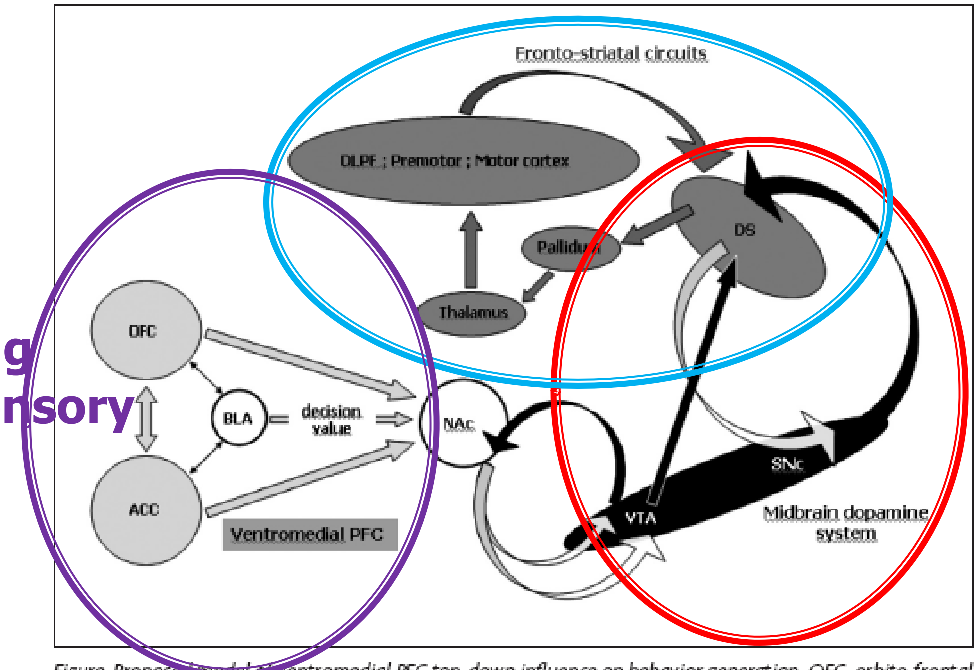
Motivation and timing interactions

Attention

Reward learning
Hedonic and sensory features

Timing



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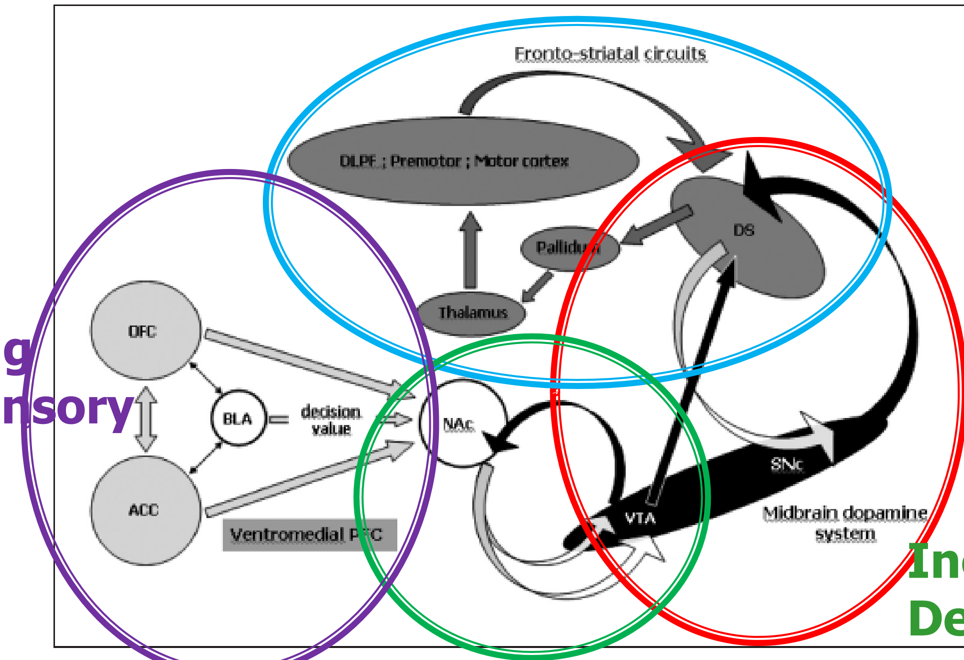
Motivation and timing interactions

Attention

Reward learning
Hedonic and sensory features



Timing

Incentive Motivation
Decision-making

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Guimarães et al. (2008)

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NAc role motivation and timing

- Neurotoxic lesions (or sham lesions) of the NAc
- Trained rats on the peak procedure (60-s FI, 180-s peak) with 1 pellet reward
- Increased reward magnitude to 4 pellets

Galtress & Kirkpatrick (2010b)

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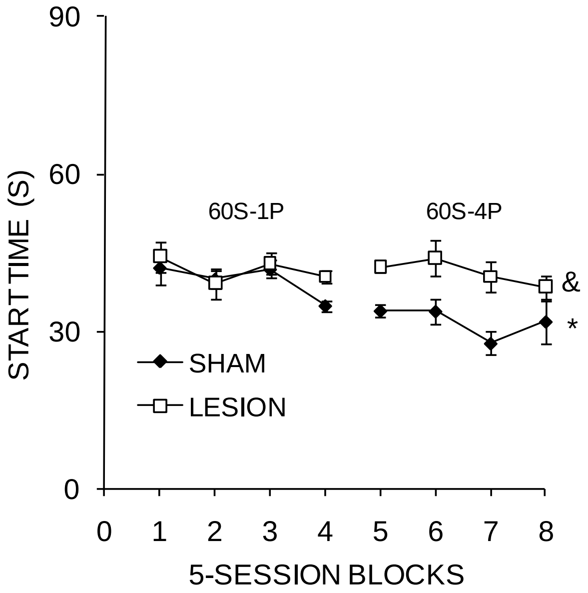

Galtress & Kirkpatrick (2010b)

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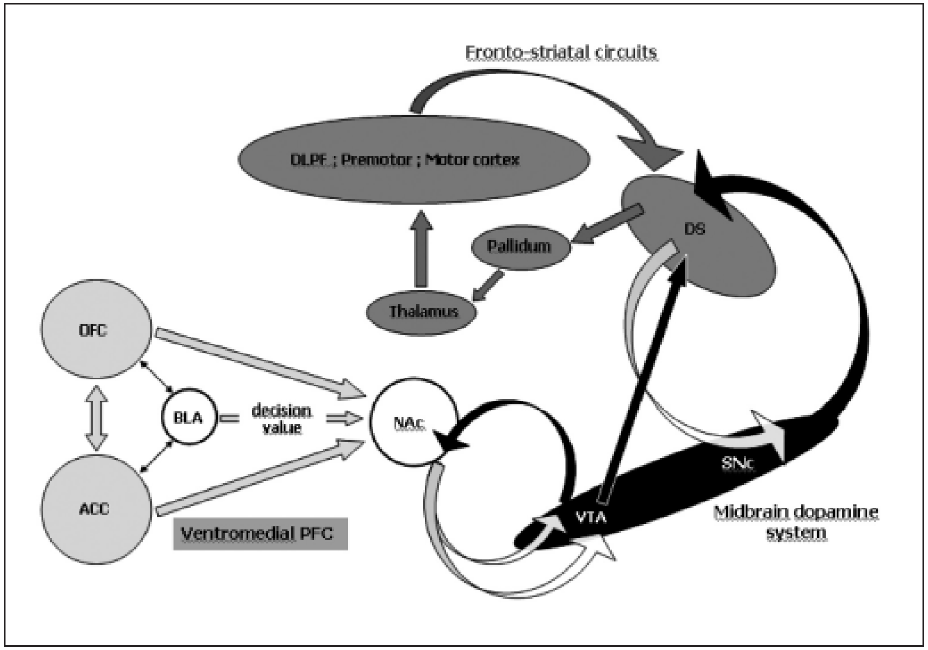
Motivation and timing interactions



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Guimarães et al. (2008)

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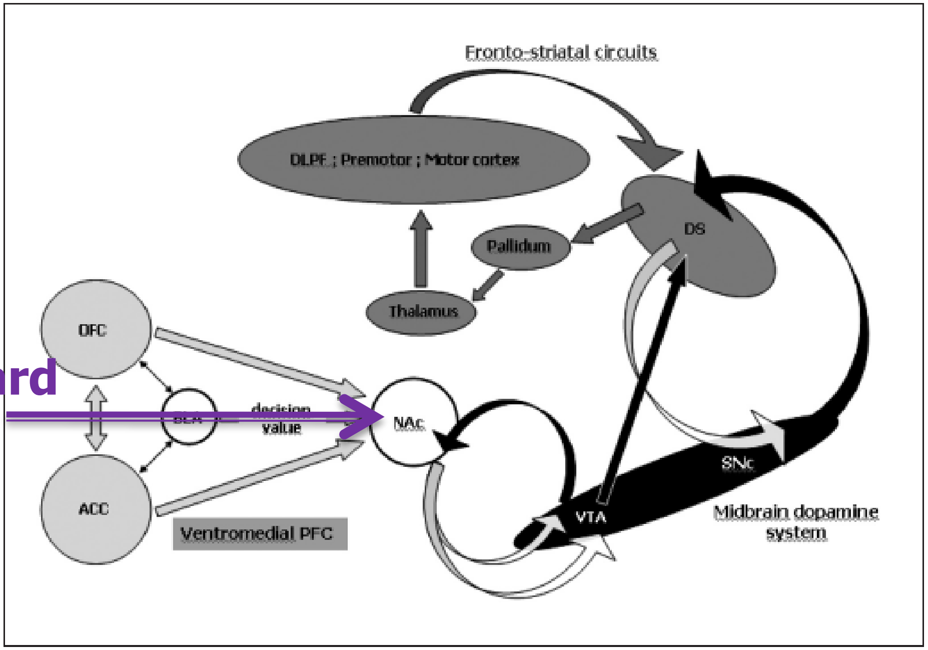
Motivation and timing interactions

Change reward value



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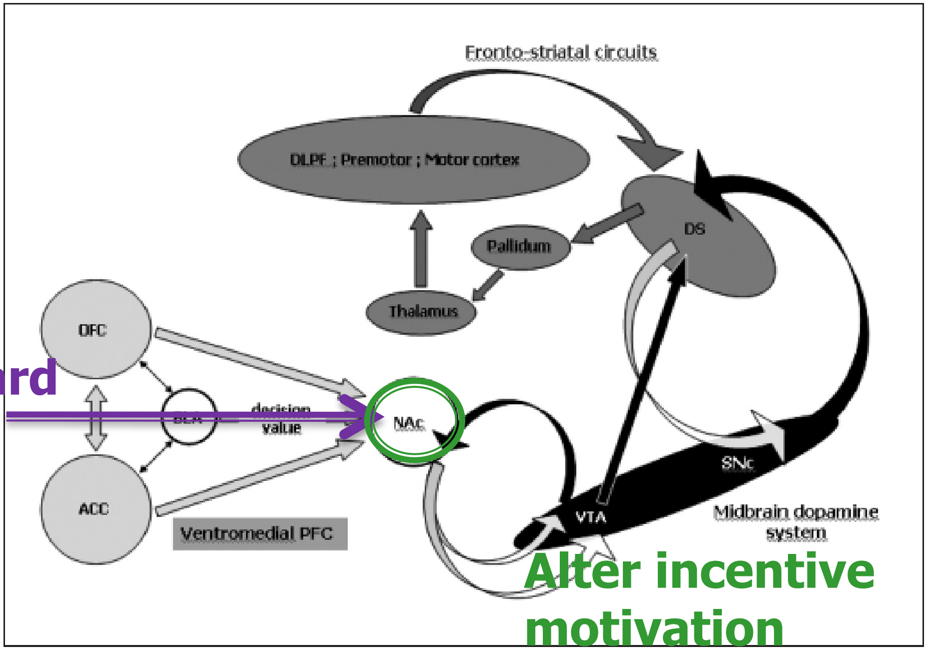
Motivation and timing interactions

Change reward value



Alter incentive motivation

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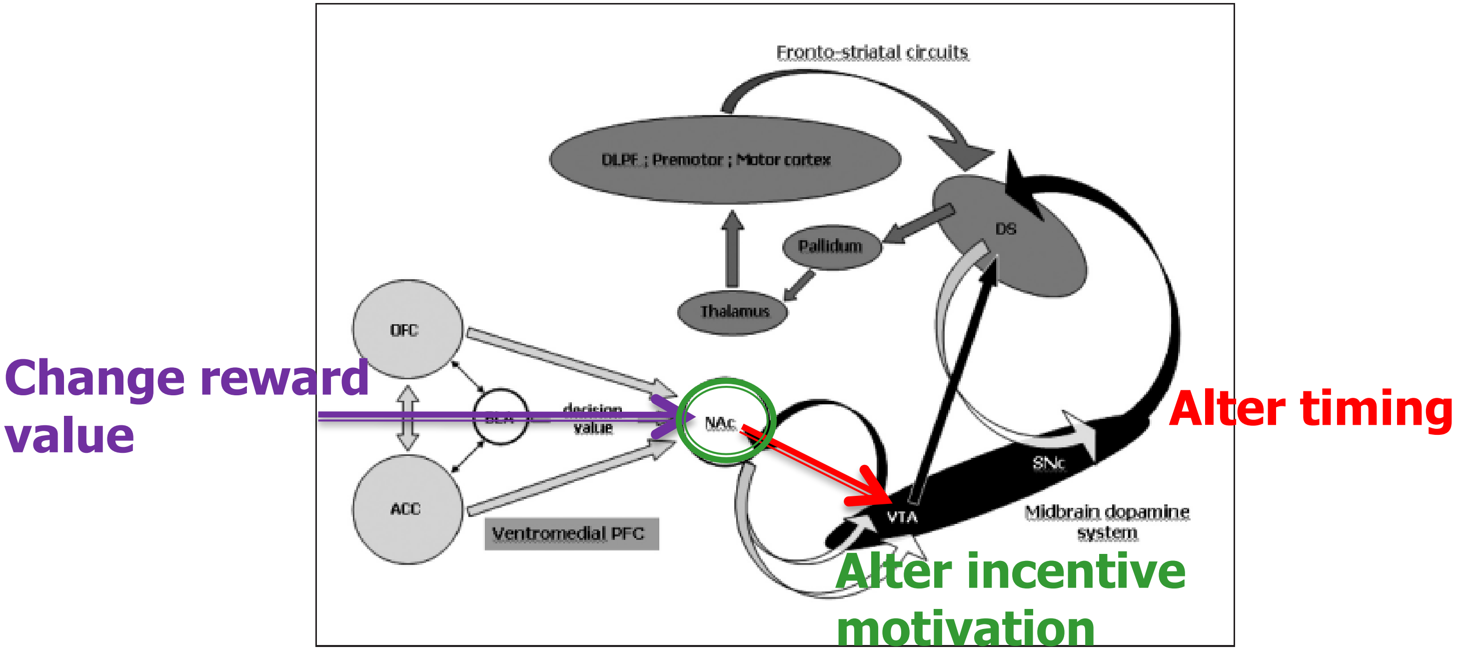
Motivation and timing interactions



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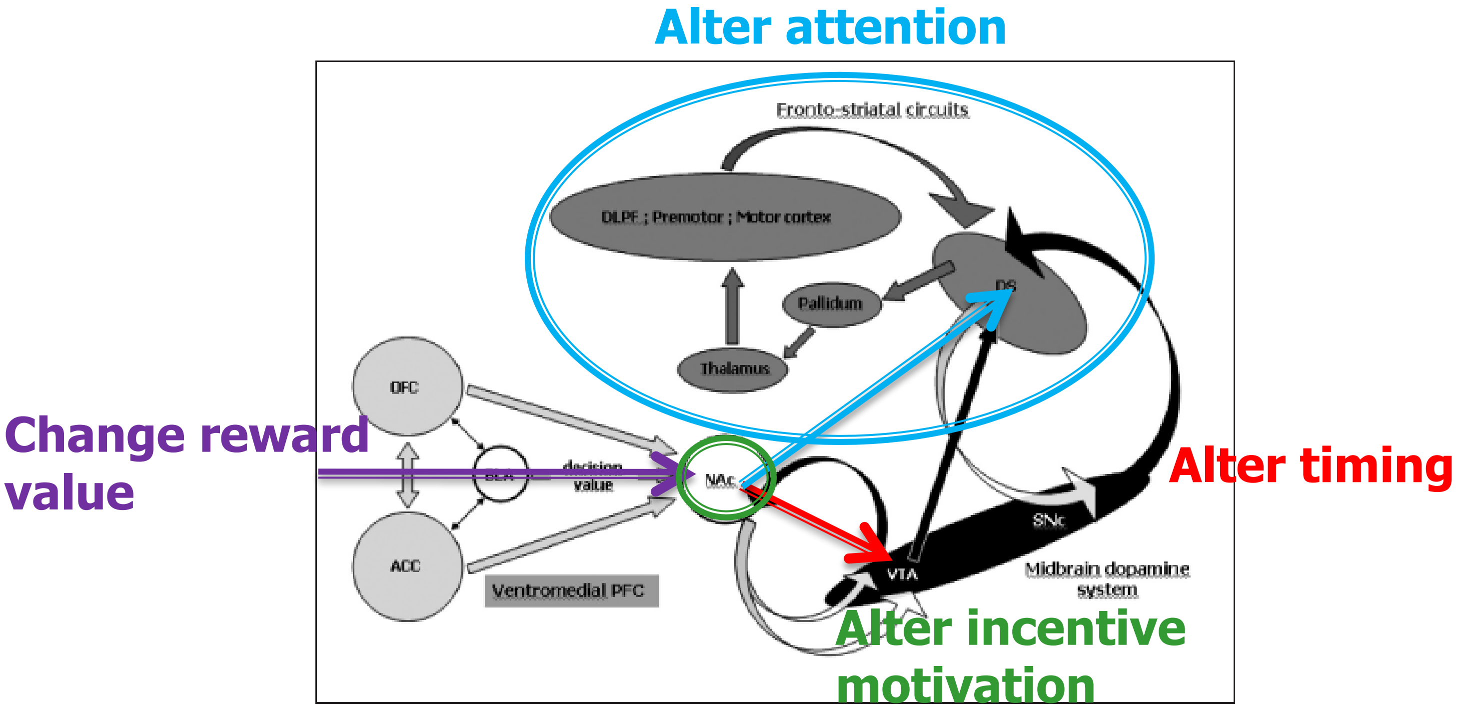
Motivation and timing interactions



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Overall summary and conclusions

- Reward magnitude and value changes altered timing behavior in both peak and bisection procedures
- Overall, the results of the bisection and devaluation (poster 19) procedures implicate the involvement of attention in modulating the effects of motivation on timing
- But, may also be occurring through a direct route

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Overall summary and conclusions

- The reward system is essential for:
  - Pavlovian and instrumental conditioning
  - Incentive motivation
  - Timing/reward anticipation
  - Decision-making/choice
    - Temporal discounting
    - Risk-taking
  - Sensation-seeking

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Overall summary and conclusions

- And, the reward system is implicated in:
  - Drug use and abuse
  - Obesity
  - Impulsivity
  - Apathy
  - Disorders such as ADHD, schizophrenia, depression

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Future directions

- Couple quantitative behavioral analysis, neuroscience, and computational modeling to create a broadly applicable "neurocomputational model of the reward system"
- Understand the circuit dynamics
  - Feedback
  - Interconnections
  - Neuronal firing patterns
- Use that understanding to guide development of a broad-based mathematical model of the system
  - What computations are being performed at each part of the circuit?
- Develop quantitative predictions→test→revise (some as yet un-determined number of iterations)

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- QUESTIONS?