An Information and Arousal-Based Model of Conditioned Reinforcement

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Introduction

- Previous research in our laboratory showed an inverse U-shaped relationship between ITI duration during Pavlovian conditioning and conditioned reinforcement.
- Theories of Pavlovian conditioning and conditioned reinforcement would predict a monotonic increasing relationship between ITI and conditioned reinforcement (e.g. Fantino et al., 1993; Shahan & Cunningham, 2015).
- Shahan and Cunningham (2015) argued for an information-based approach to conditioned reinforcement utilizing temporal information.
- Longer ITI durations result in more informative stimuli by increasing cycle time (Balsam et al., 2010).

H_{com} = $\log_2$(Cycle Time/Trial Time)

- Because H_{com} is positively associated with ITI duration, an information-based approach alone would not predict the observed inverse-U shape.
- Additionally, the TRC performed worse in the conditioned reinforcement test than a paired condition with the same H_{com} value.

Methods

- 70 male rats
- ITI varied across 6 groups (55s – 4780s)
- Seventh group served as a truly random control with two independent 1200s timers
- CS duration 20s
- 12 sessions Pavlovian delay conditioning
- New-Response (FR1) testing

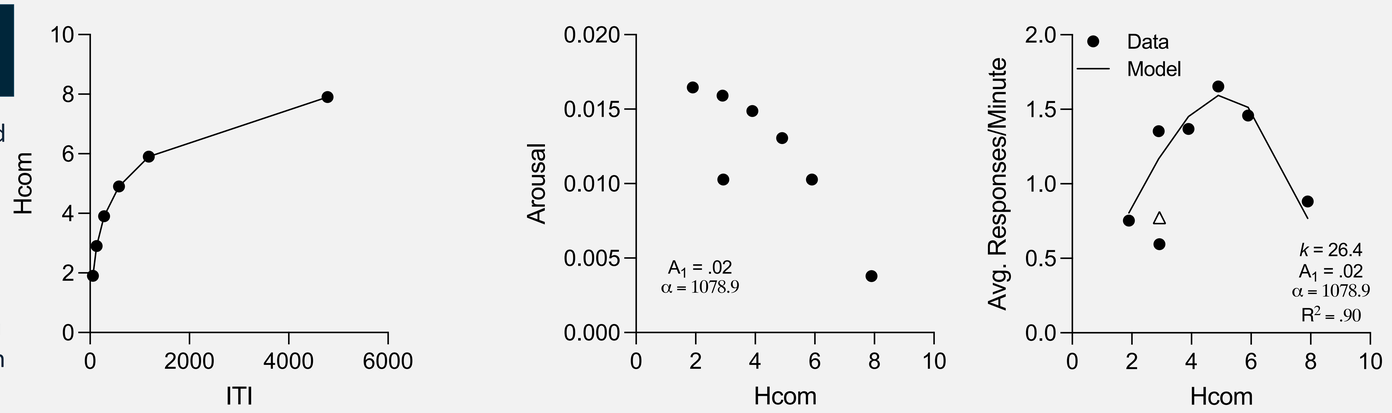

Figure 1. Hcom, arousal, and final model predictions for the current experiment. The paired data points in the final model figure represents the data and model prediction for the TRC condition.

Model

$$B = \frac{kH_{com}}{H_{com} + 1/A}$$

- H_{com} = temporal informativeness
- k = asymptotic response rate (responses/minute)
- A = average arousal during a Pavlovian training session

$$A = \frac{\sum_{i=1}^{n} \frac{A_1 \alpha}{T}\left(1 - e^{-\frac{n_i T}{\alpha}}\right)}{n}$$

- Arousal is calculated using Equation 10 from Killeen (1978), which calculates average arousal over a trial.
- The above equation takes an average of those averages to generate an overall average arousal value for the entire Pavlovian training session.
- n_i = trial number
- n = total number of trials per Pavlovian training session
- T = interval between foods (s)
- α = time constant (s)
- A_1 = arousal at T = 0

Fit Methods

- Model was fit to group averages of the sum of active responses over four days of new response testing converted to responses/minute.
- Microsoft Excel Solver was used to obtain parameter values for k, α, and A_1.

Discussion

- Here, the inclusion of an arousal term is meant to account for the extremely low overall reinforcement rate in long ITI conditions.
- Arousal is negatively related to ITI duration and *t,* if all other variables are held equal.
- Therefore, the model would predict a simple monotonic decreasing relationship between *t* and conditioned reinforcement.
- The current model assumes no accumulation of arousal between sessions, which is unlikely.
- Exploration of other calculations of arousal at different points of pavlovian training is warranted.

References

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