How over interpretation of simple behavioral models can lead to unexpected results: In search of the optimal sampling distributions for delay values on the Restaurant Row Task

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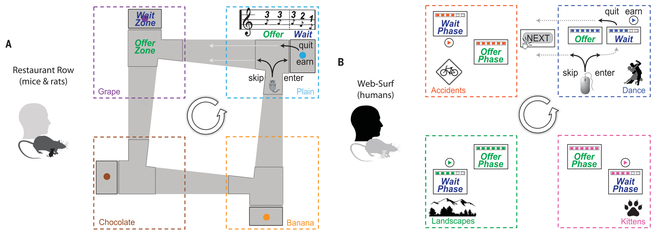
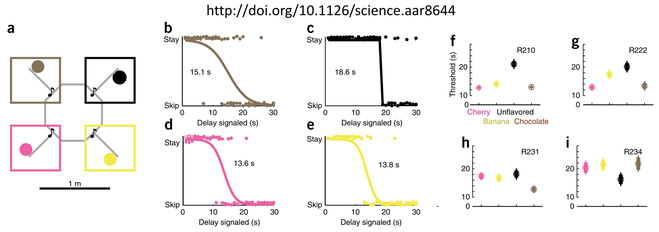
Background

In the Restaurant Row task (Steiner and Redish 2014) animals make sequential wait/skip decisions at 4 feeder locations offering different flavors of food with a randomly chosen delay on each visit. The probability of waiting out a particular delay length vs skipping it is used to determine animal's preference for each food flavor. Specifically, the animal's preferences on this task are modeled by fitting a logistic function to their probability of waiting for a reward as a function of delay length. The threshold values of these logistic functions represent the relative value of each reward option. The longer animals are willing to wait, the more valuable the reward. Previously delay values were sampled randomly from a uniform distribution, which results in a large number of easy decisions (delays well below or above threshold will be accepted or rejected at nearly 100% rates). In order to maximize the information gained from each feeder visit, it would be optimal to sample most heavily near the threshold of the sigmoid function where the information density of each decision is the highest. However we discovered that this sampling pattern had unintended consequences on the animal's behavior on the task.

The Restaurant Row Task



Sweis, B. M., Abram, S. V., Schmidt, B. J., Seeland, K. D., MacDonald, A. W. I., Thomas, M. J., & Redish, A. D. (2018). Sensitivity to "sunk costs" in mice, rats, and humans. Science (New York, NY), 361(6398), 178–. http://doi.org/10.1126/science.aar8644



Steiner, A. P., & Redish, A. D. (2014). Behavioral and neurophysiological correlates of regret in rat decision-making on a neuroeconomic task. Nature Neuroscience, 17(7), 995–1002. http://doi.org/10.1038/nn.3740

Modeling Decisions on Restaurant Row

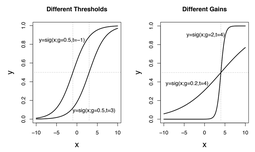
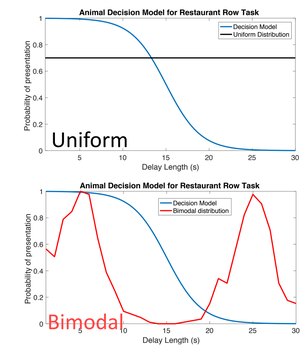


Figure 14.6: Examples of sigmoid functions of a single variables. The left panel shows sigmoids with the same gain but different thresholds. The right panel shows sigmoids with the same threshold but different gains.

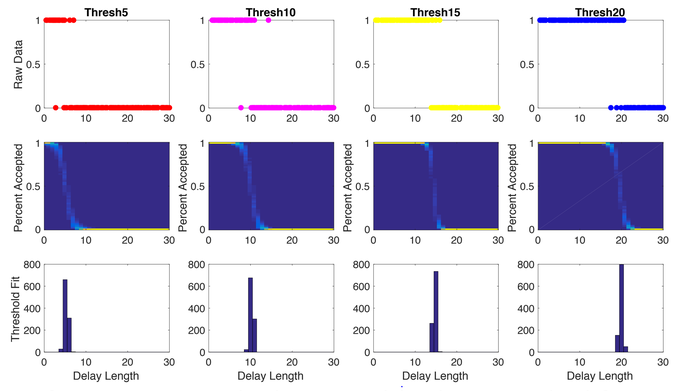
Kruschke, J. (2014). *Doing Bayesian data analysis: A tutorial with R, JAGS, and Stan*. Academic Press.

$$y \sim \text{dbern}(\mu) \qquad \mu = \frac{1}{1 + e^{(-\gamma(x-\theta))}}$$



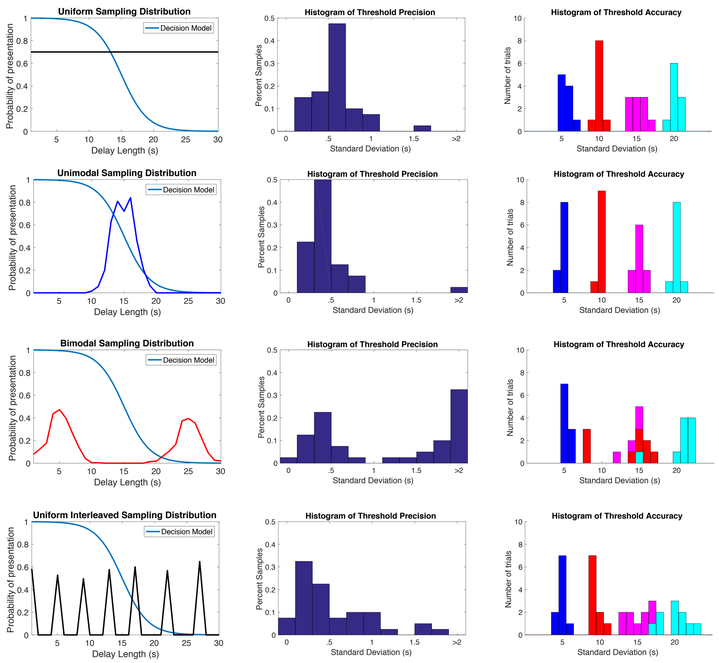
On this task we model animal's decisions as a logistic function. Optimal sampling for this function would weight sampling nearer the threshold.

Bayesian Logistic GLM



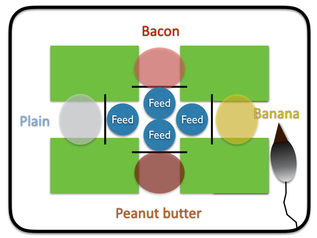
We fit a Bayesian Generalized Linear Model with a Logistical Link function using JAGS in Matlab. This model uses numerical methods to find a probability distribution over the threshold for the logistic decision model.

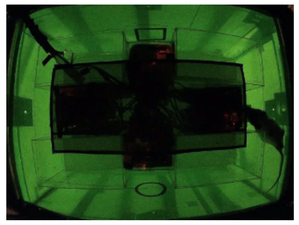
Simulation: Precision and Accuracy of different sampling distributions



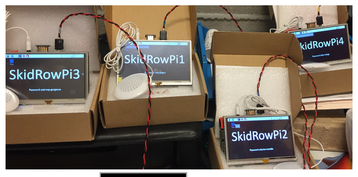
We simulated 4 sets of 50 trials with an actual threshold at 5, 10, 15, and 20 seconds, and tested the precision and accuracy of the different sampling distributions on the measured thresholds from the Bayesian GLM.

Modified Restaurant Row Task: Skid Row



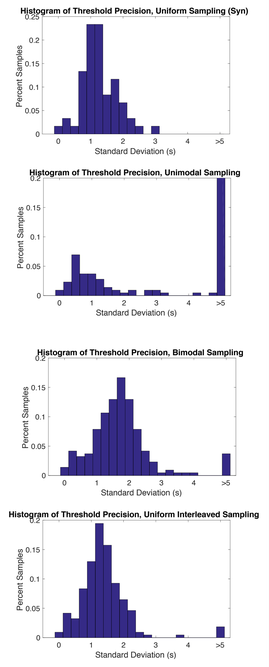


We modified the restaurant row task geometry so animals could be recorded from below

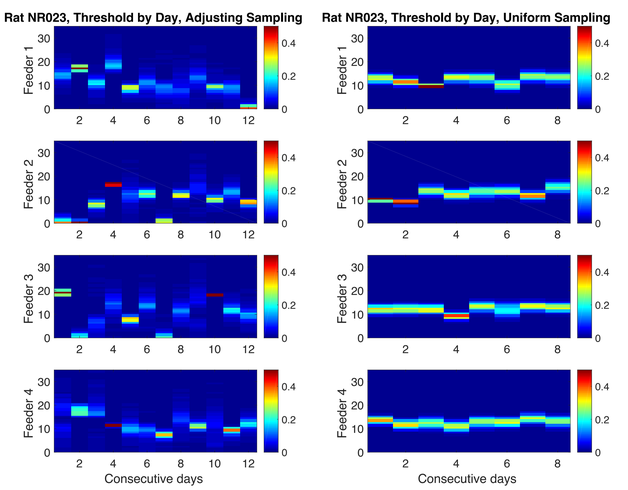


We used 4 individual raspberry Pis to control each feeder zone, playing countdown tones and displaying a visual stimulus of the amount of time remaining in each zone, and firing the feeders if the animal waited out the delay

Precision from Rat Data

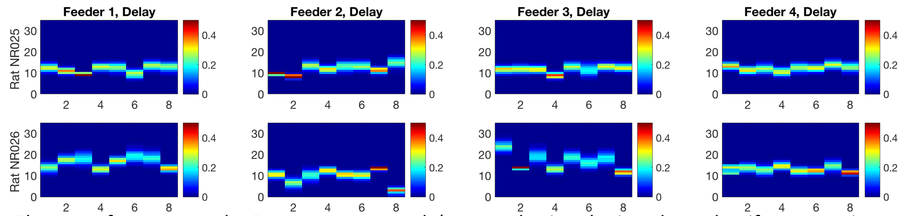


What goes wrong with Unimodal Sampling?



The unimodal sampling paradigm presents the animals with a small array of choices relative to the other options, and there is less advantage to be gained by avoiding high delays or choosing low delays, hence the actual flavor preferences displayed on the task are less consistent and meaningful.

How Consistent are Flavor Preferences on the Restaurant Row Task?



Flavor preferences on the Restaurant row task (assessed using the interleaved uniform samping model) are relatively stable, but do vary, especially in some animals.

Conclusions

- ✓ Optimal sampling for a simplified theoretical model may have unintended consequences on actual animal behavior
- ✓ flavor preferences on the restaurant row task are similar to human flavor preferences, in that they are generally consistent but vary day by day

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