Robust inference and modeling of social effects on mice learning in Intellicages

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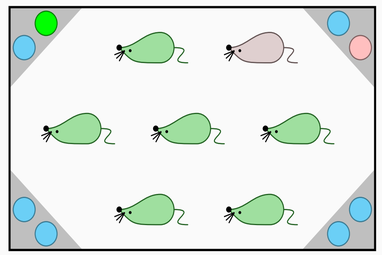


Social learning experiment design

- 14 mice freely interacting in an Intellicage box
- animals randomly grouped into **majority** (12) and **minority** (2)
- two reward corners (saccharin solution) separately for **majority** and **minority**
- access to reward conditional on animal assignment matching corner assignment

Animals' task: learn the location of reward under mutual influence.

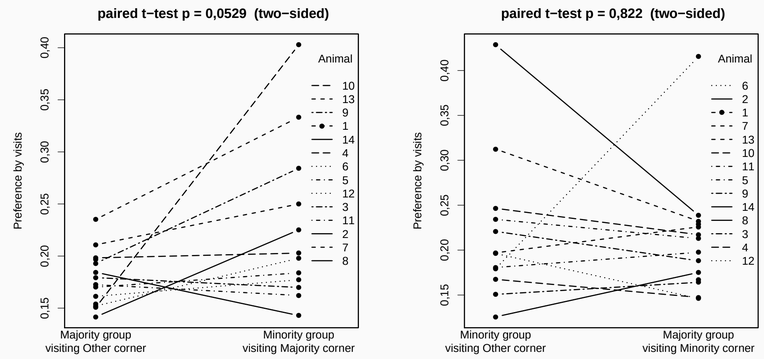
Mathematical formulation

Every instant t_i an animal i enters or leaves a corner constitutes a transition of state. The activity of each mouse i is described by sequences $\mathrm{H}_i = \{t_{i,1} \dots t_{i,J_i}\}$ $S_i = \{s_{i,1} \dots s_{i,J_i}\}$ $s_{i,j} \in \{0,1,2,3,4\}$ where 0 denotes the arena and $1,\dots,4$ denote Intellicage corners. The above can be modeled as a **marked point process** in terms of stochastic intensity of visits and a probability distribution of choices.

$$\lambda_{i,j\to k}(t|H(t)) = \lim_{h\to 0} \frac{P\left(N_{i,j,k}(t+h) - N_{i,j,k}(t) = 1|H(t)\right)}{h} = \lambda_{i,j}(t|H(t)) \cdot P_{j\to k}(t|H(t))$$

We fit both $\lambda_{i,j\to k}(t|H(t))$ and $P_{j\to k}(t|H(t))$ using maximum likelihood estimation.

Social effects



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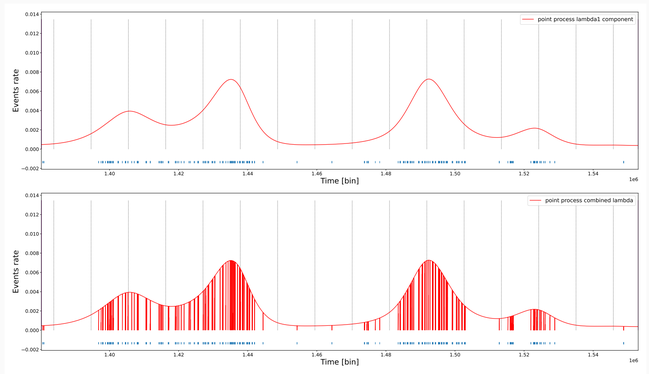
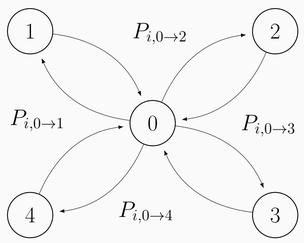
$\lambda_{i,j}$: Visit times as point process



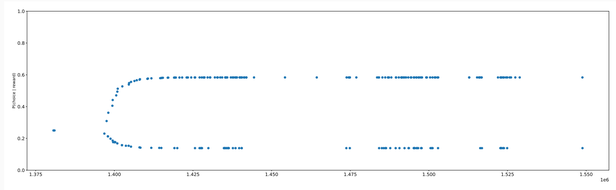
$P_{j\to k}$: Corner choices as reinforcement learning



$$P_{i,0\to k}(t|H(t)) = \frac{e^{\beta_i v_{i,j}(t)}}{\sum_i e^{\beta_i v_{i,j}(t)}}$$

Rescorla-Wagner rule for choice valuation as baseline model

$$v_{i,k}(t) = v_{i,k}(t-) + \alpha_i \left(r_{i,k} - v_{i,k}(t-)\right)$$



We consider extensions, including social effects.

Conclusions

- We propose a general statistical framework for description, analysis and modeling of animal behavior in intelligent cages.
- The framework combines marked point process description with reinforcement learning and allows estimation and comparisons different models of learning.
- On example data from an experiment with majority and minority groups we show an effect of social learning in the Intellicage.