Changing prior probability in perceptual decision making

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Introduction

Signal detection theory: Unequal prior probabilities → shift in decision criterion

Previous studies: Most vary category probability between blocks, assume a fixed criterion, and explicitly state probability (e.g., Refs. 1, 2). Few examine decision-making behavior as category probabilities change over time.

Q1: Can observers track sudden changes in category probability?

Q2: How is prior probability estimated?

Method

Experimental protocol

Covert-criterion task
“Which category does the ellipse belong to? A or B?”

Overt-criterion task
“Rotate the line to indicate your criterion”

Stimulus generation

Category distributions
Random step-wise changes in \( p(A) \)

Behavioral Results

Representative observer

Modeling Results

Maximum a posteriori (MAP) fits for a representative observer

Models

Fixed Criterion (FIXED)
- F Wrocław criterion between the category means

Bayesian online change-point detection
- Ideal observer (BAYES_IDEAL): Marginalizes over the current run length (time since last change) and the current category probability
- Suboptimal 1 (BAYES_RUN): Observer with a potentially incorrect belief about the distribution of run lengths
- Suboptimal 2 (BAYES_PROB): Observer with a potentially incorrect belief about the distribution of probability states
- Suboptimal 3 (BAYES_BIAS): Observer with a bias towards equal priors (\( p = 0.5 \))

Exponential averaging
- Exponential (EXP): Estimates probability as an exponentially weighted average of previously seen categories
- Exponential with bias (EXP_BIAS): Exponential observer with a bias towards equal priors (\( p = 0.5 \))

Reinforcement-learning on criterion (RL)
- Updates criterion by a proportion of the error in orientation when receiving negative feedback

Conclusions

A1: Yes. Observers track sudden changes in probability with a conservative bias towards equal priors.

A2: Observers estimate prior probability as an exponentially weighted average of previously experienced categories with bias towards a prior of 0.5.