Computational mechanisms of human state-action-reward contingency learning under perceptual uncertainty

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MPI for Human Development and Freie Universität Berlin

Economic Decision Making

Economic Decision Making

Approach

Avoid

Economic Decision Making Under Perceptual Uncertainty

Summerfield and Tsetsos, 2012; Fleming et al., 2013; Lak et al., 2017; Starkweather et al., 2017; Schutte et al., 2017

Economic Decision Making Under Perceptual Uncertainty

???

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Summerfield and Tsetsos, 2012; Fleming et al., 2013; Lak et al., 2017; Starkweather et al., 2017; Schutte et al., 2017

Economic Decision Making Under Perceptual Uncertainty

To which degree do humans take their subjective perceptual uncertainty into account when learning to make economic decisions under perceptual uncertainty?

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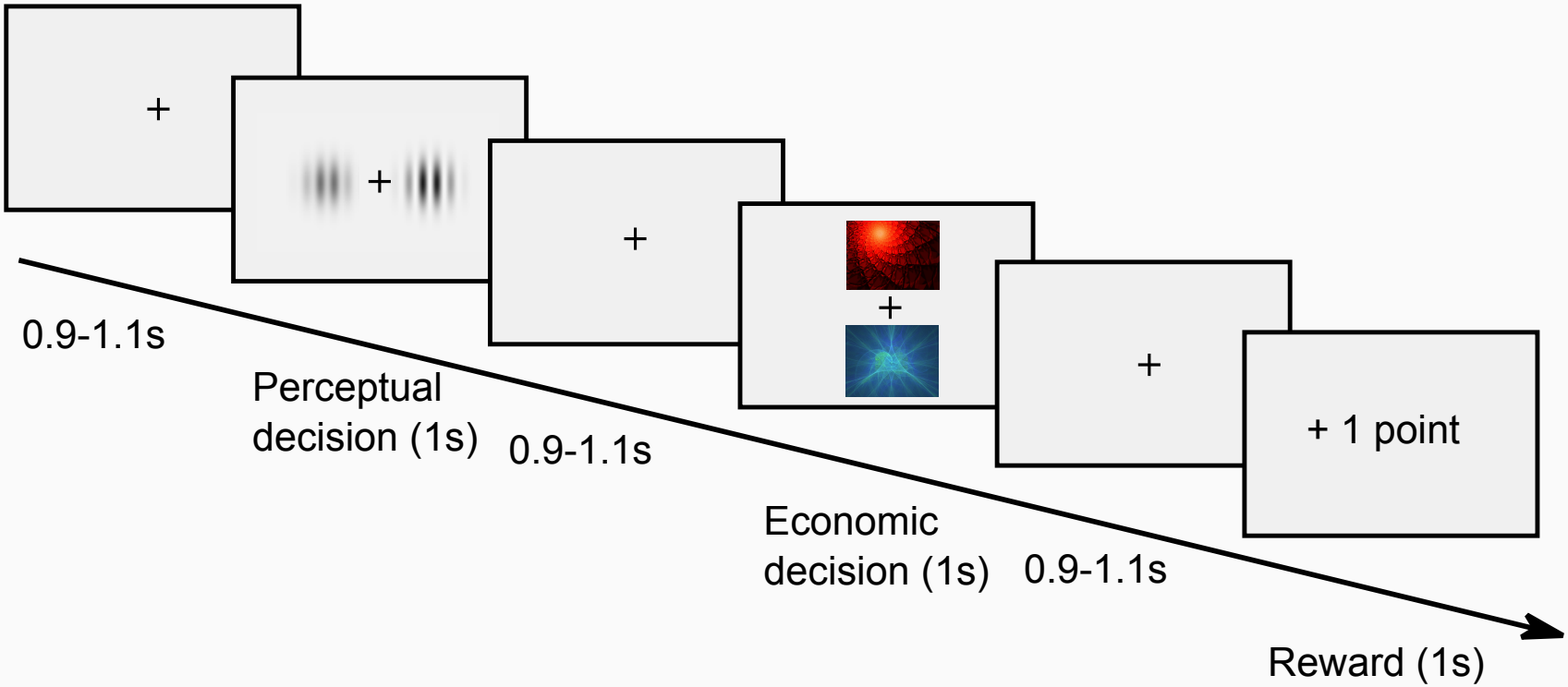
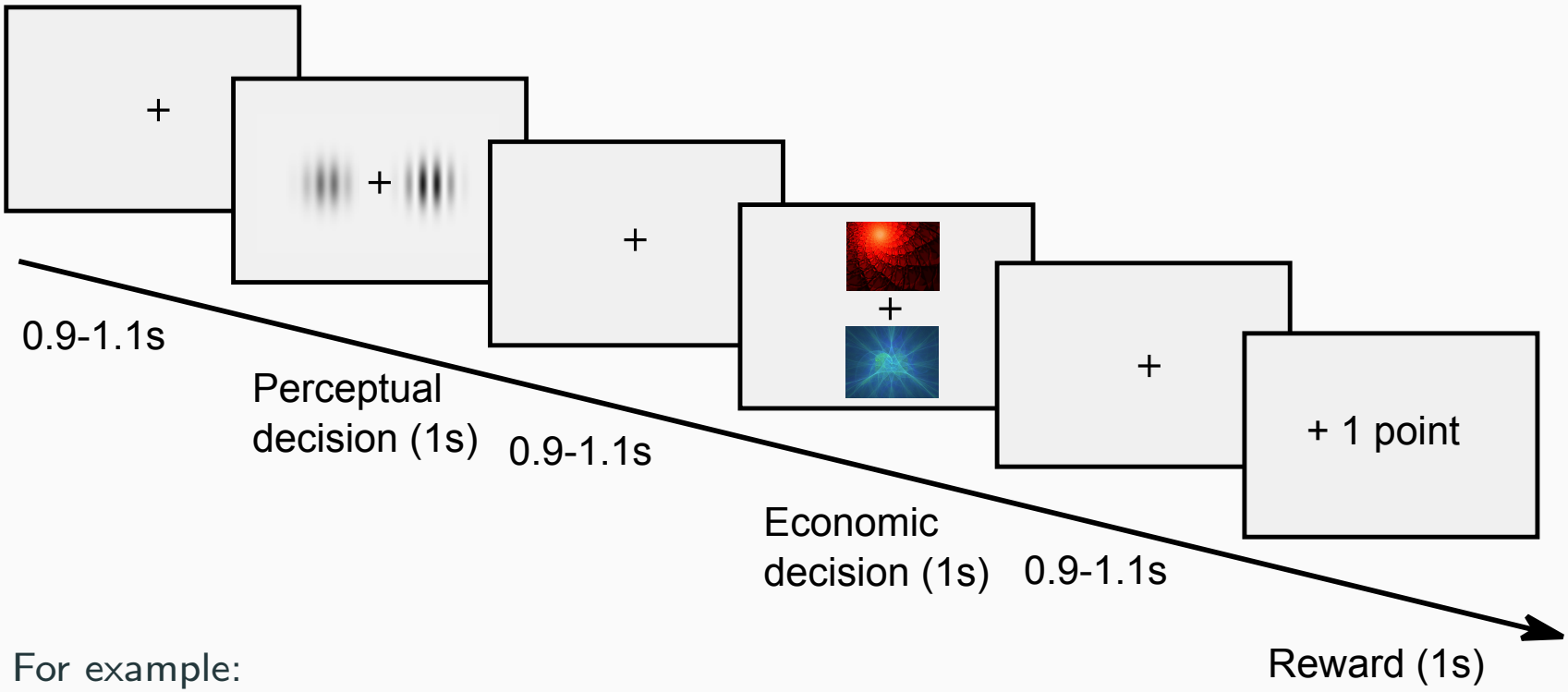
Summerfield and Tsetsos, 2012; Fleming et al., 2013; Lak et al., 2017; Starkweather et al., 2017; Schutte et al., 2017

Gabor-Bandit Task



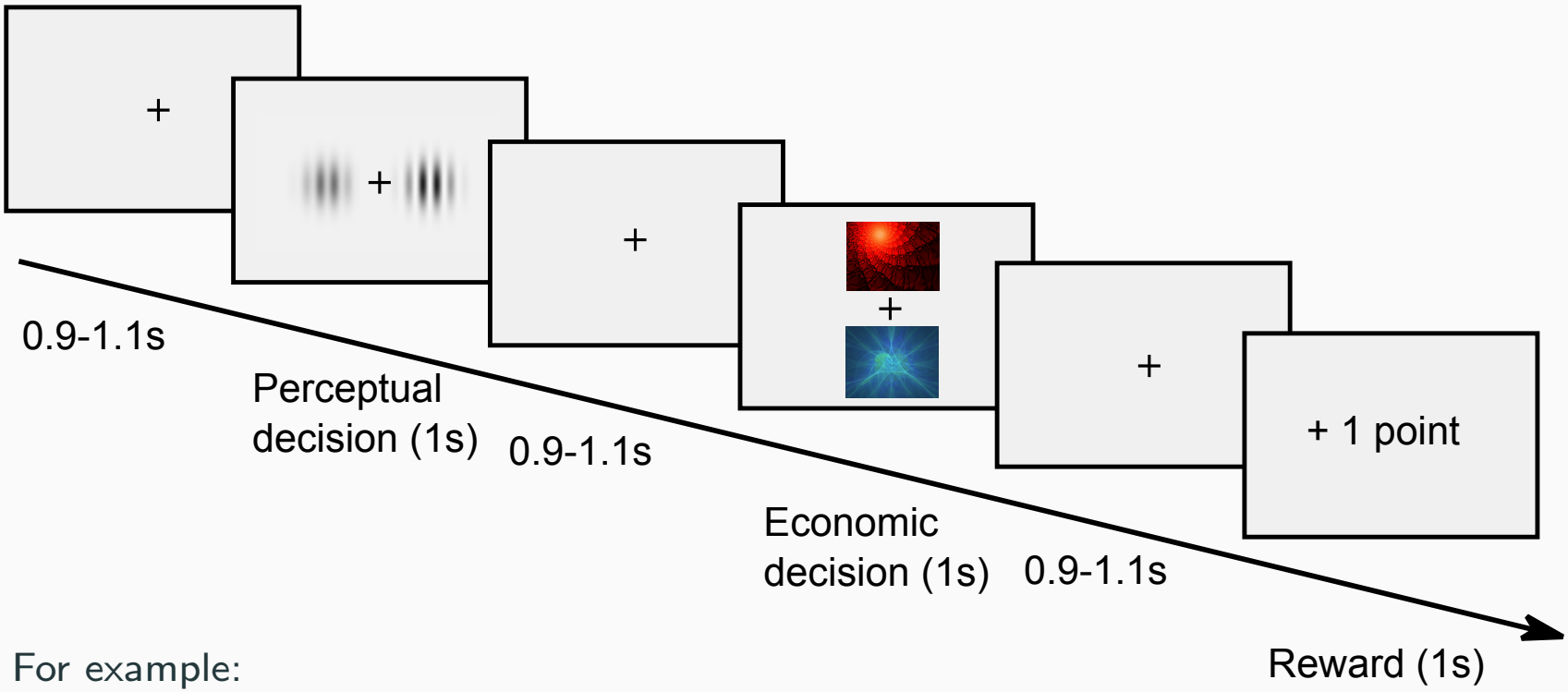
Gabor-Bandit Task



For example:

Left Gabor patch $\rightarrow$ red fractal

Gabor-Bandit Task

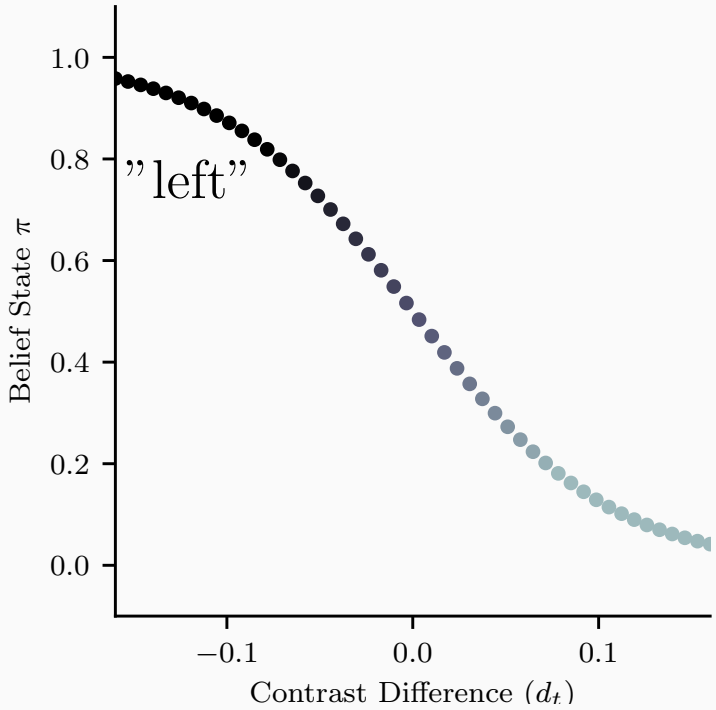


For example:

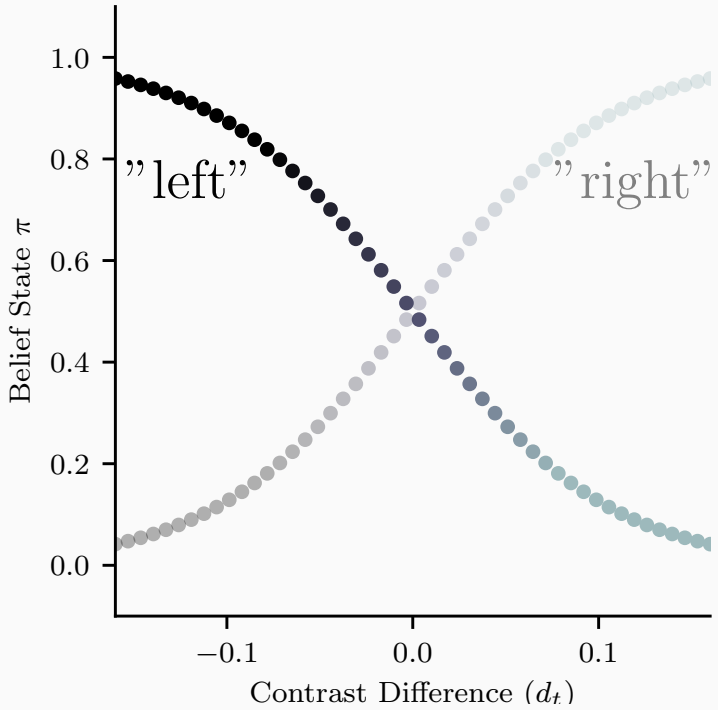
Left Gabor patch $\rightarrow$ red fractal

Right Gabor patch $\rightarrow$ blue fractal

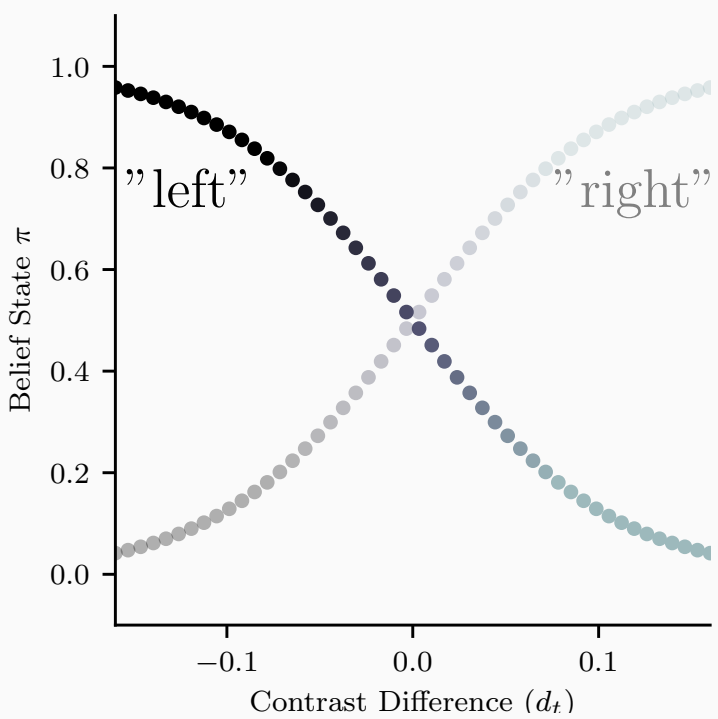
Bayes-Optimal Model: Simulations

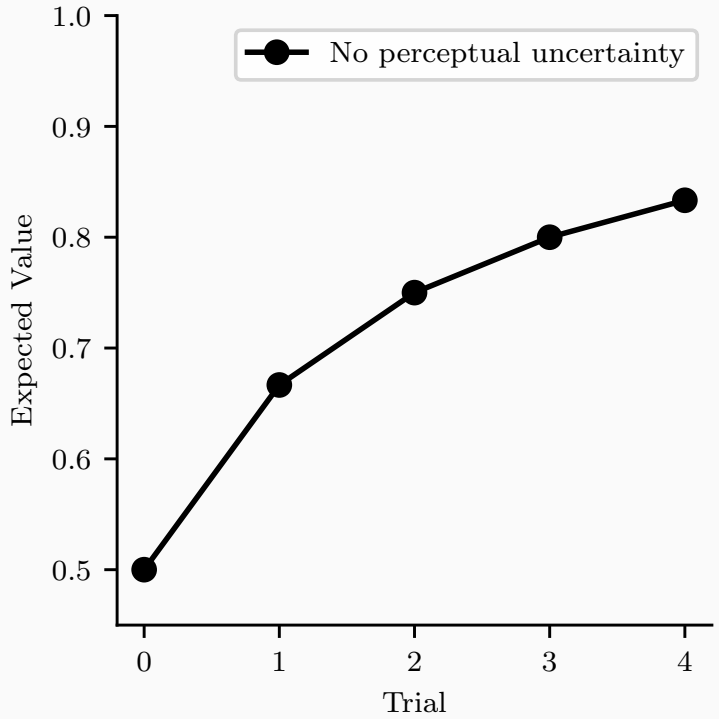


Bayes-Optimal Model: Simulations

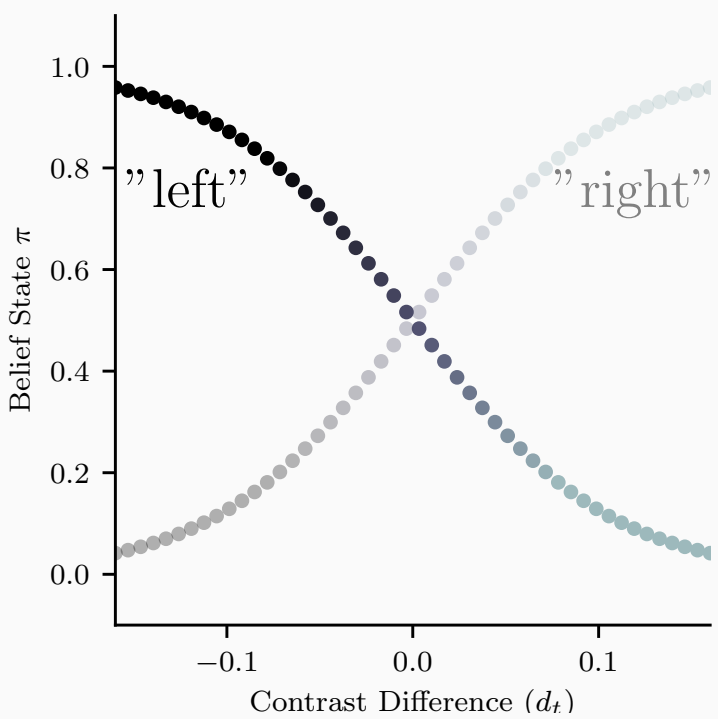


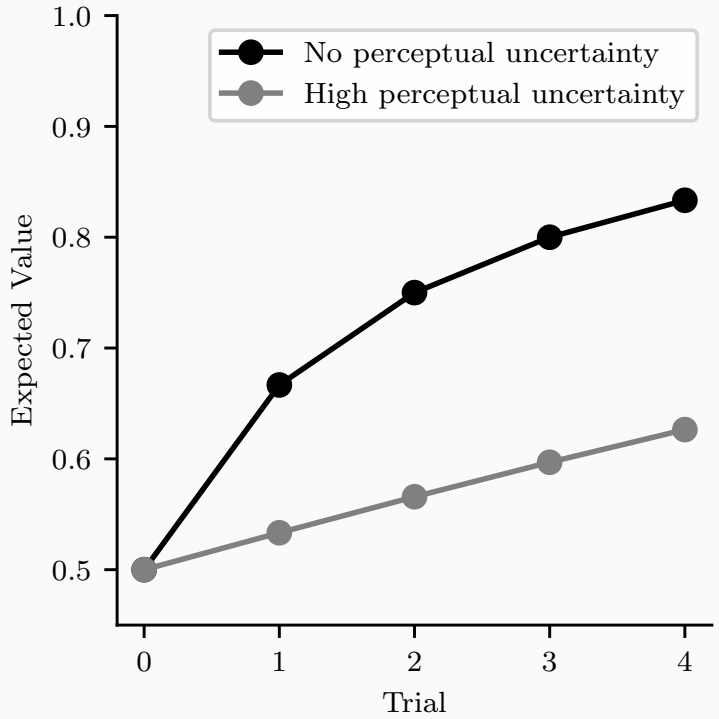
Bayes-Optimal Model: Simulations



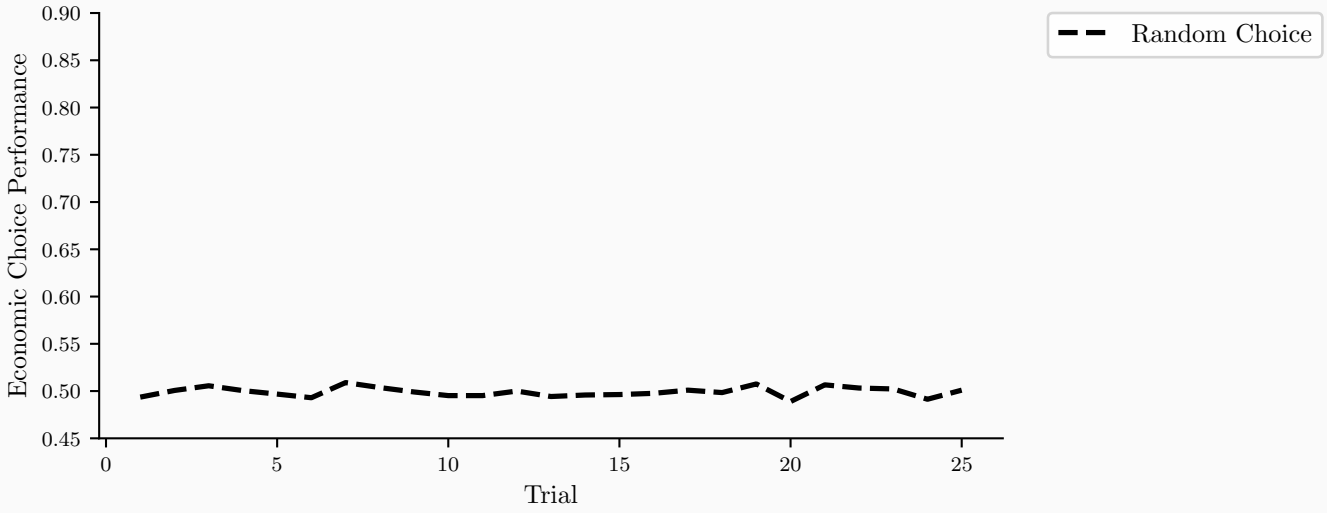


Bayes-Optimal Model: Simulations



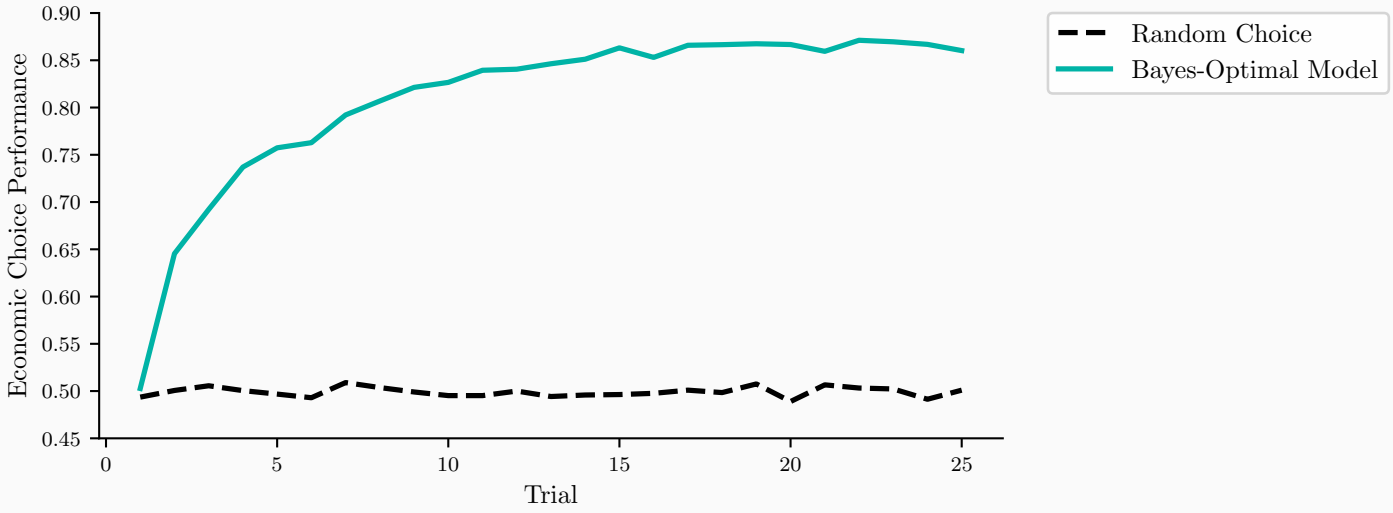


Model-Based Analyses: Random Choice Model



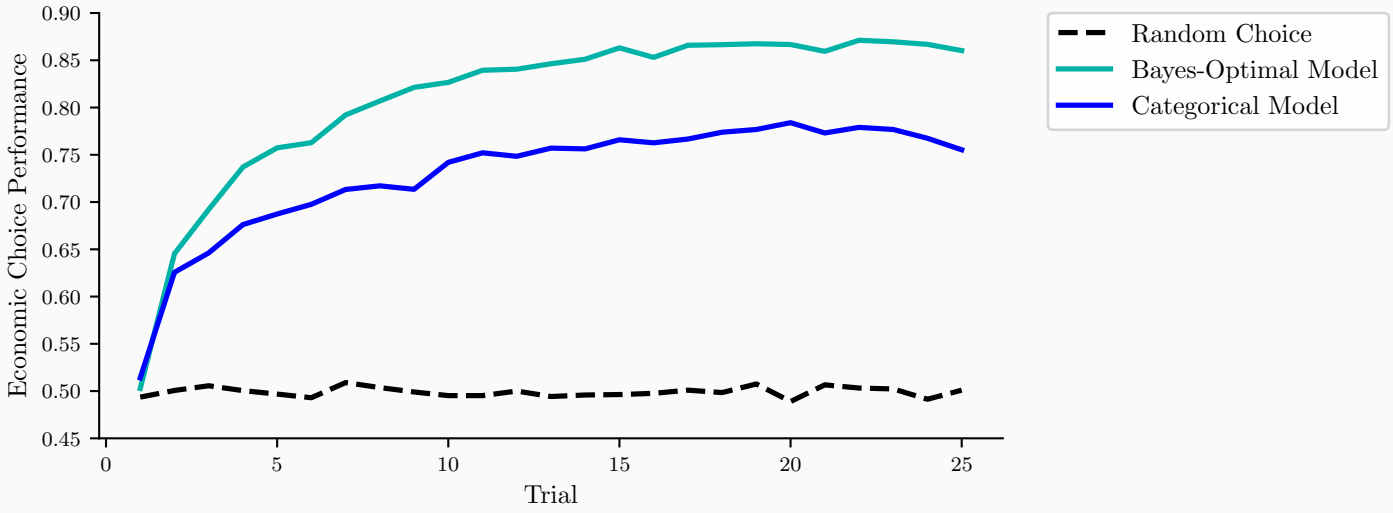
n = 52 younger adults

Model-Based Analyses: Bayes-Optimal Model



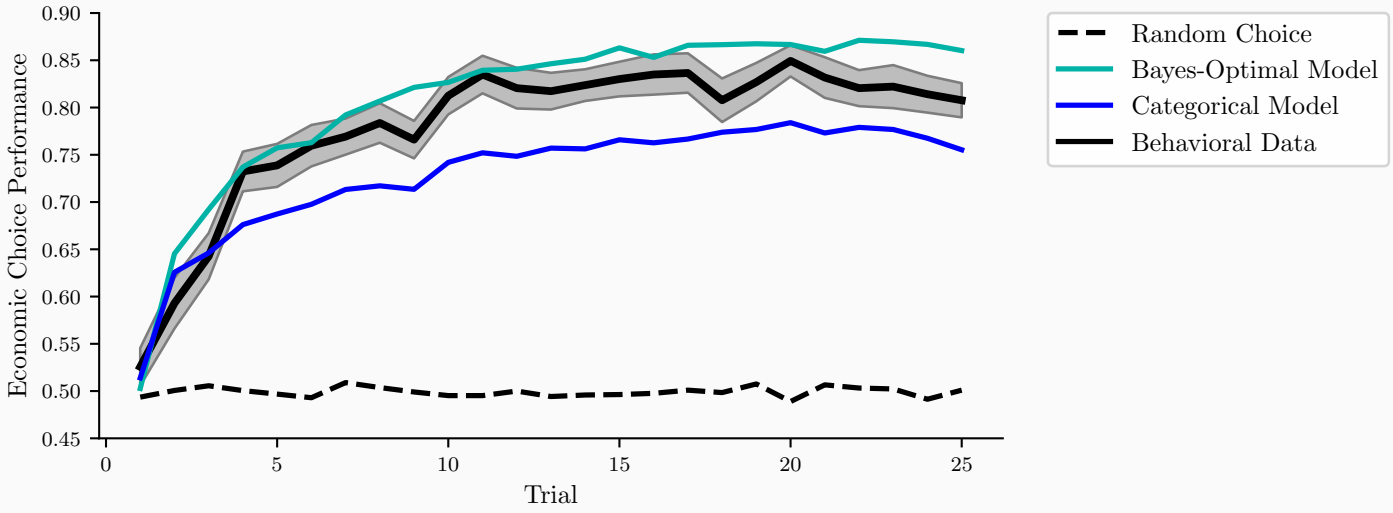
n = 52 younger adults

Model-Based Analyses: Categorical Model



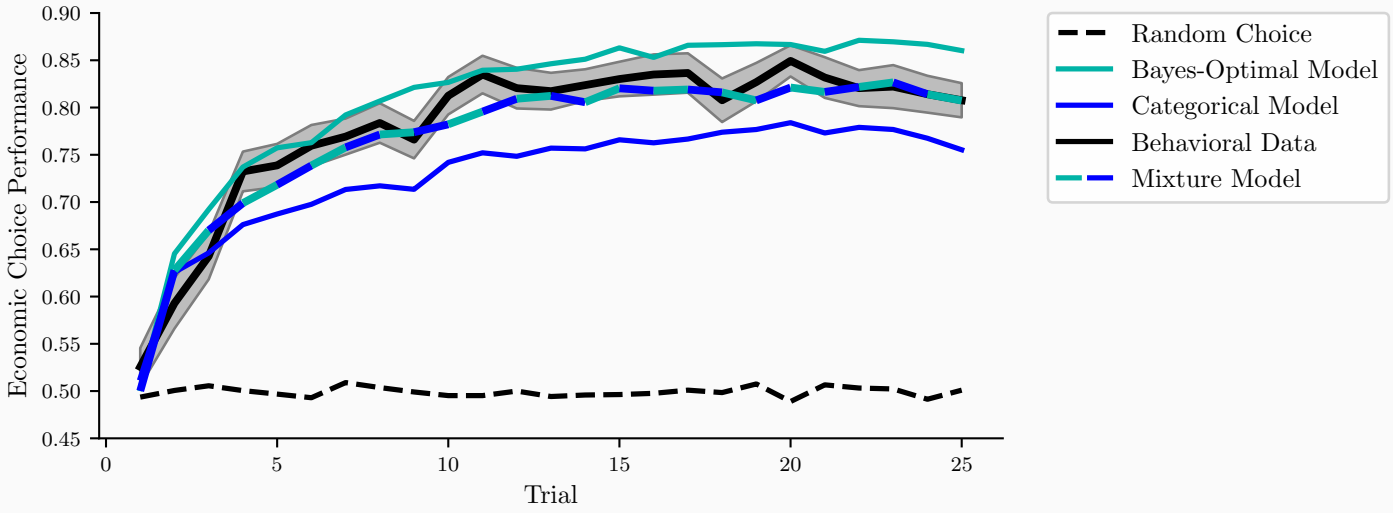
n = 52 younger adults

Model-Based Analyses: Behavioral Data



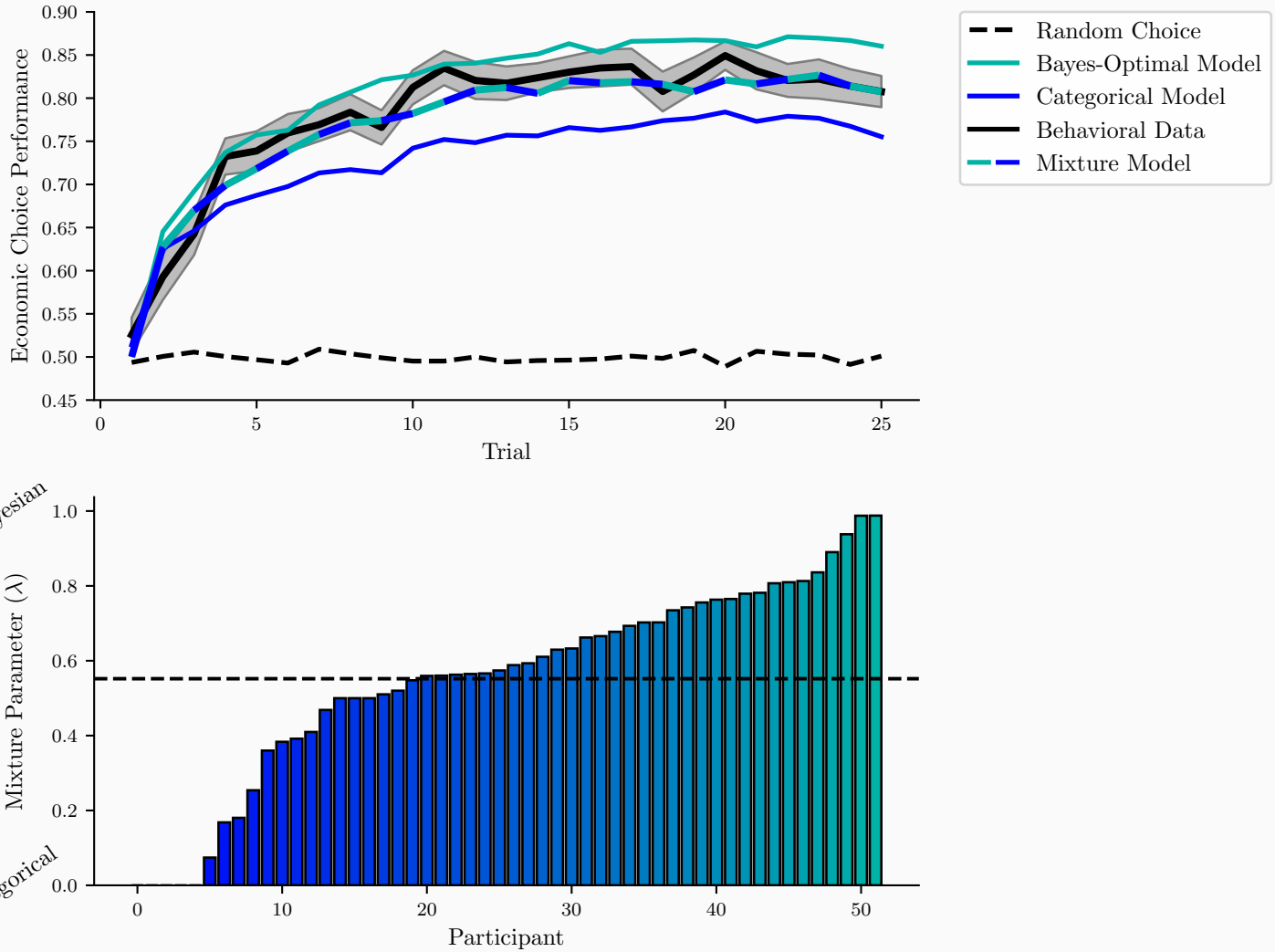
n = 52 younger adults

Model-Based Analyses: Mixture Model



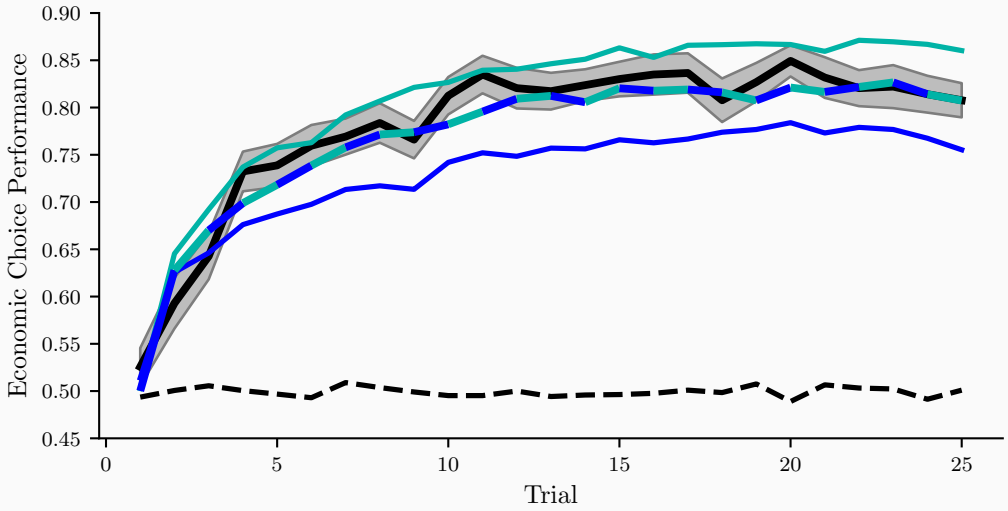
n = 52 younger adults

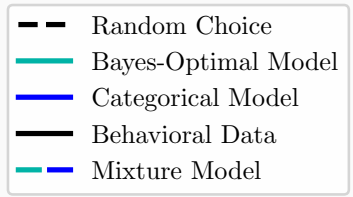
Model-Based Analyses: Mixture Parameter

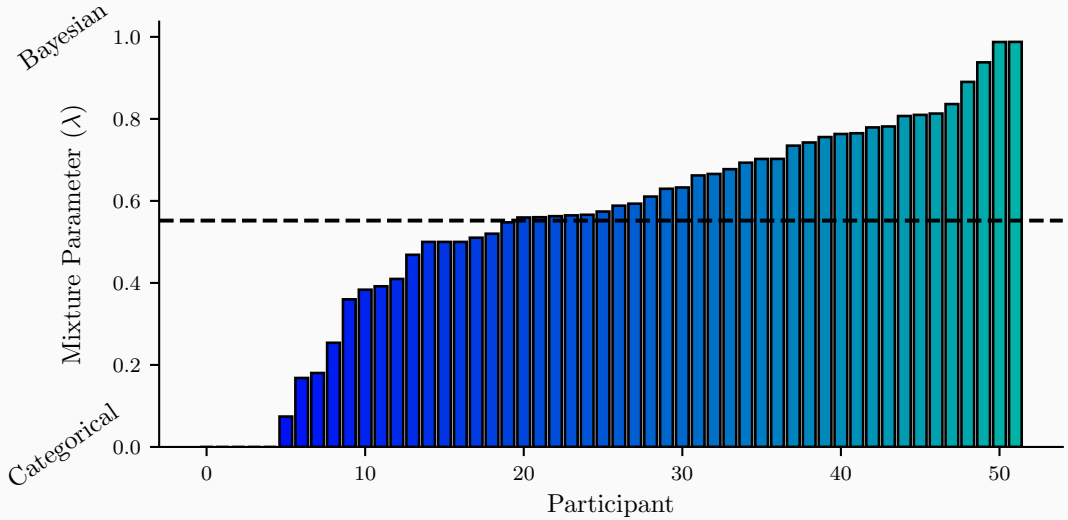


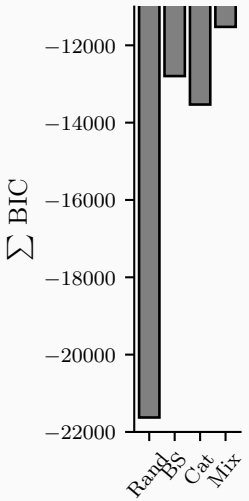
n = 52 younger adults

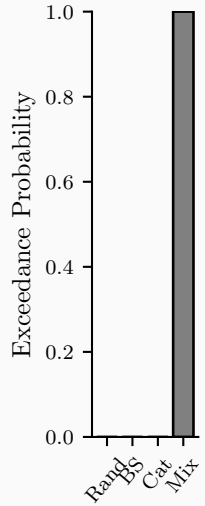
Model-Based Analyses: Model Comparison











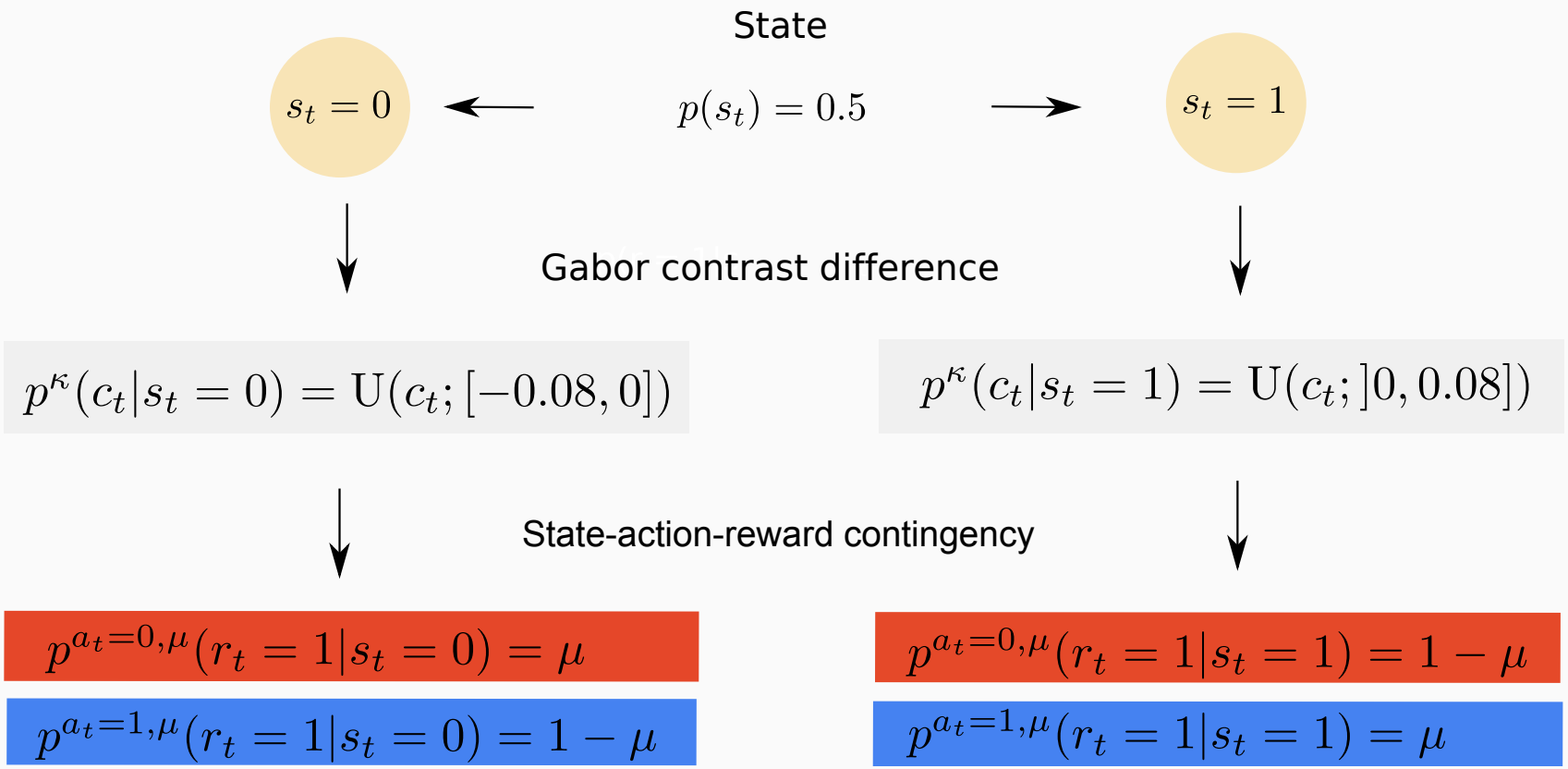
n = 52 younger adults

Conclusion

- Humans integrate their subjective perceptual uncertainty when learning probabilistic state-action-reward contingencies
- They tend, however, to underestimate the degree to which they should do so from a normative Bayes-optimal perspective

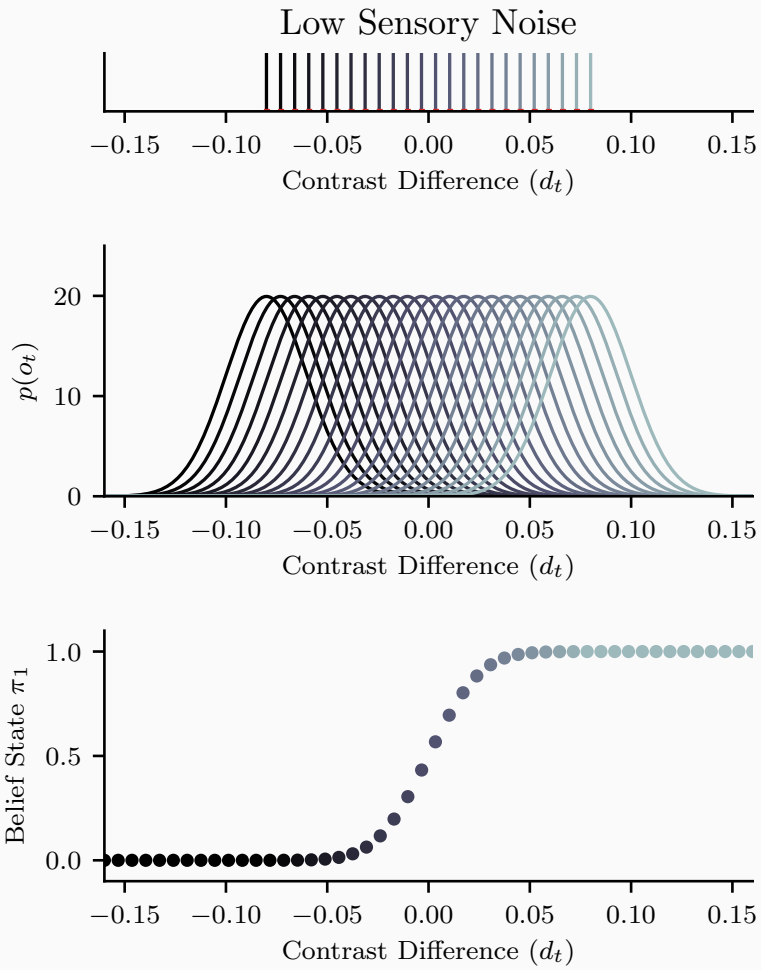
Thank you!

Gabor-Bandit Task

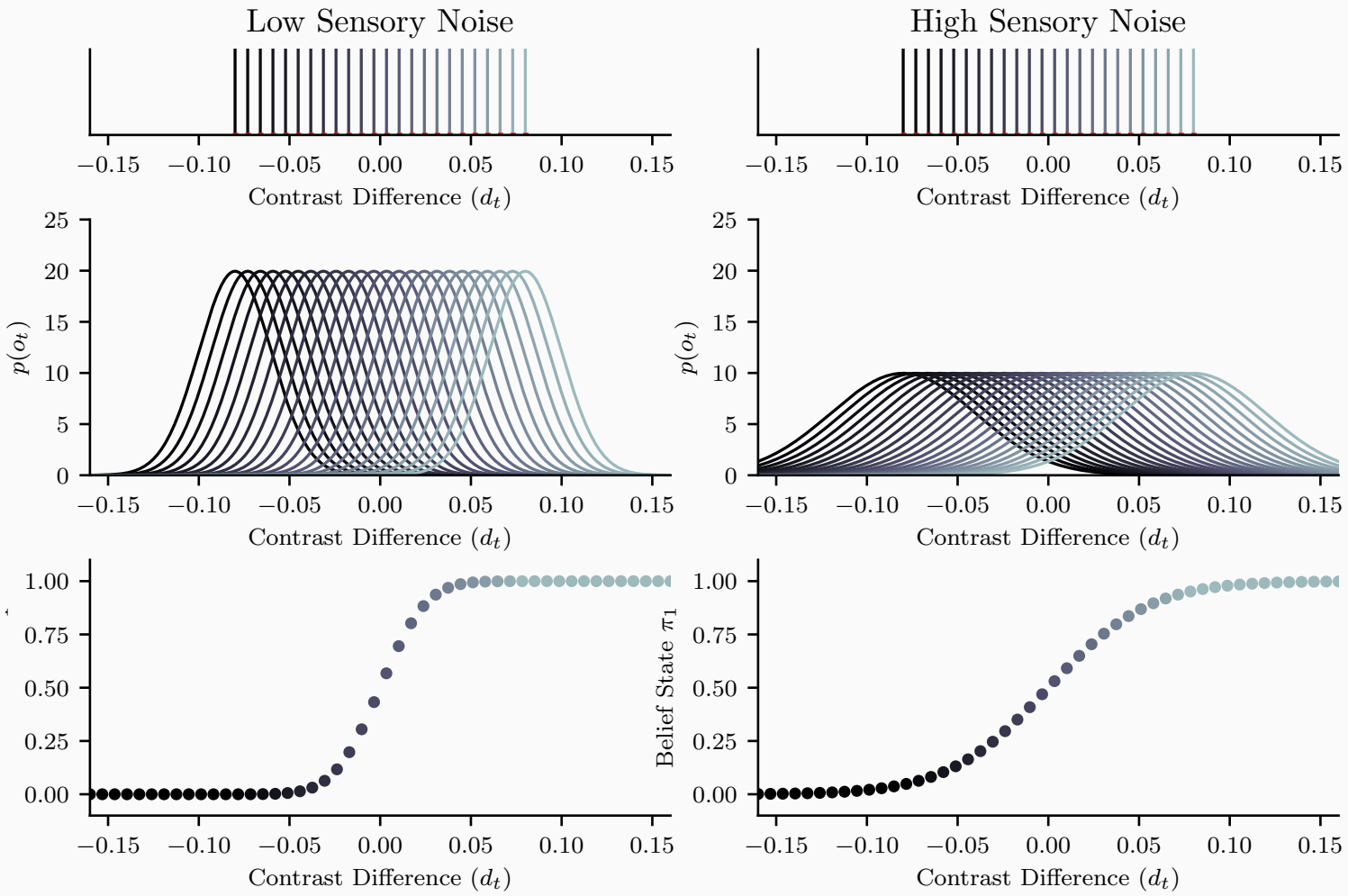


Play/Pause | Media Caption

Behavioral Modelling - Perception



Behavioral Modelling - Perception



Behavioral Modelling - Learning

Belief-state weighted sequential Bernoulli updating where uncertainty about expected reward $\mu \in [0, 1]$ is governed by order-increasing polynomials

$$p^{a_{1:t}}(\mu | r_{1:t}, o_{1:t}) = \sum_{k=0}^{t} c_{t,k} \mu^{t-k}$$

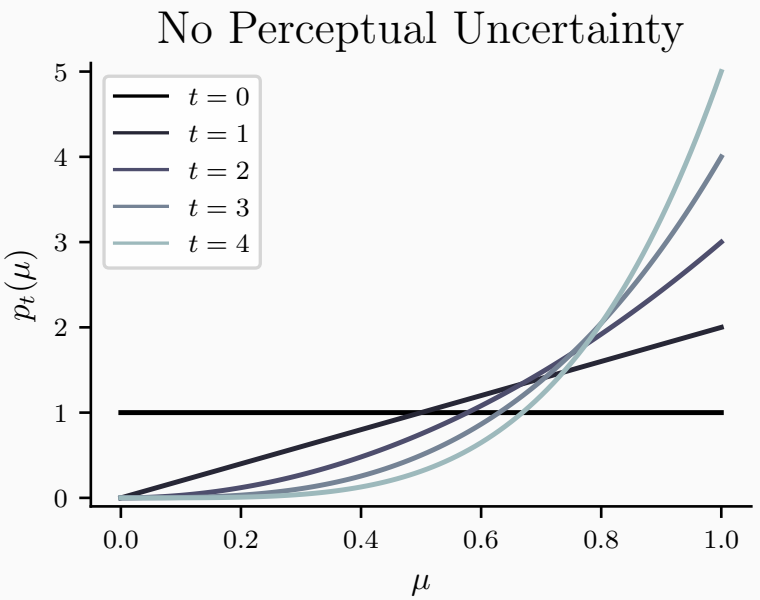
$$c_{t,0} = q_1 c_{t-1,0}$$

$$c_{t,k} = q_1 c_{t-1,k} + q_0 c_{t-1,k-1}$$

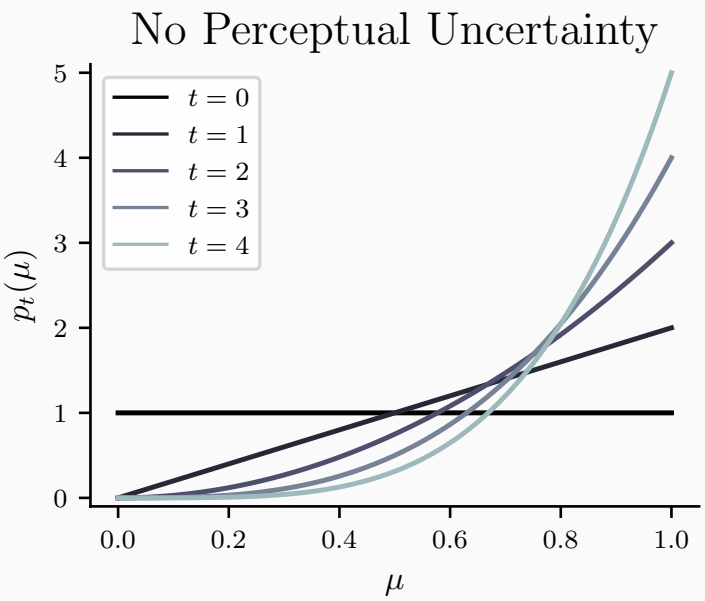
$$\text{for } k = 1, 2..., t-1$$

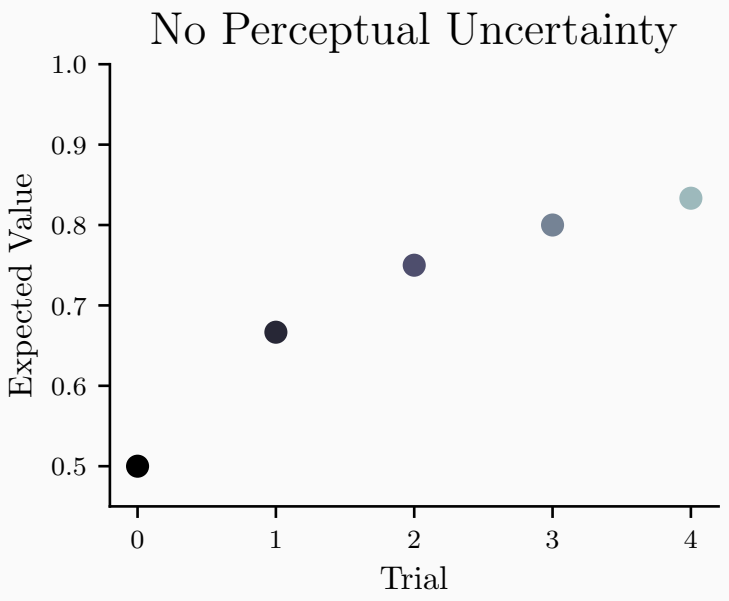
$$c_{t,t} = q_0 c_{t-1,t-1}$$

Behavioral Modelling - Learning

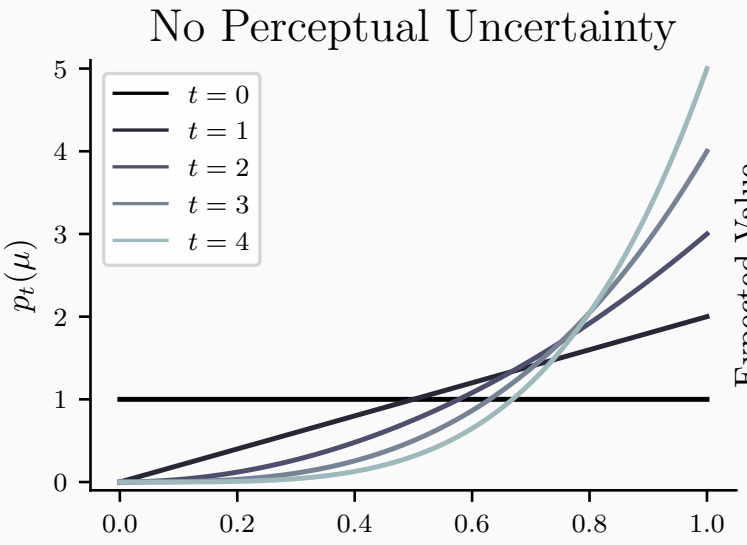


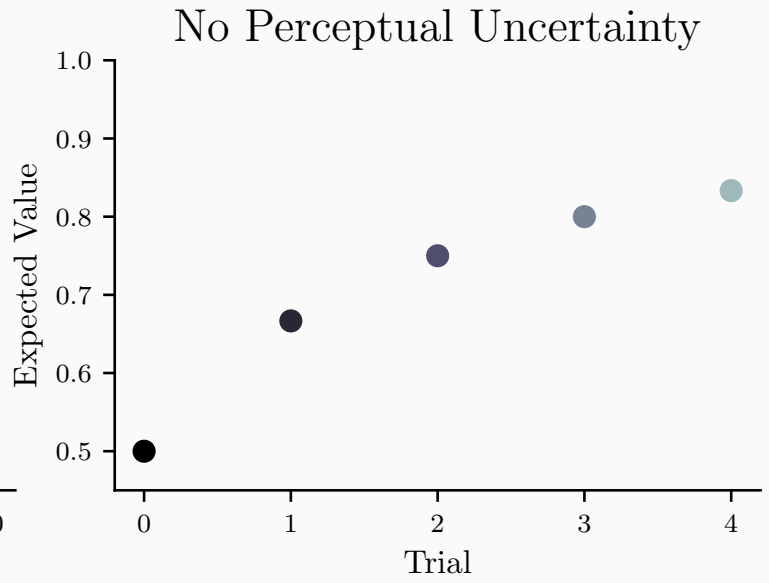
Behavioral Modelling - Learning

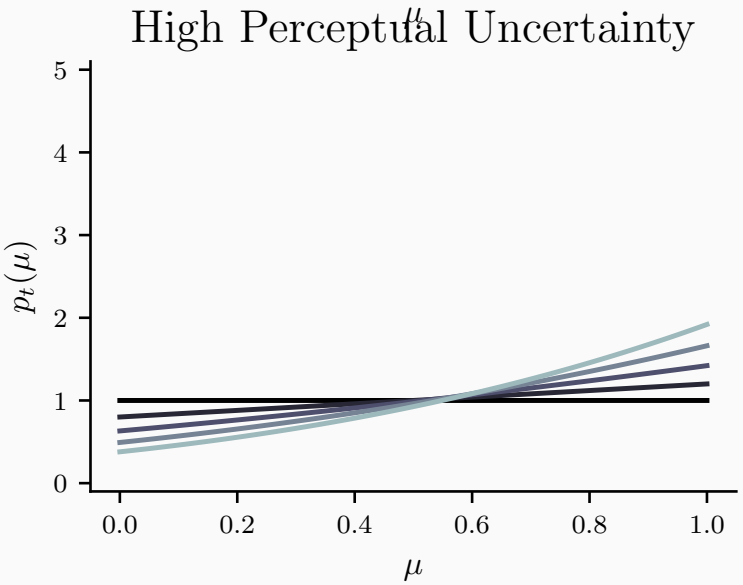




Behavioral Modelling - Learning







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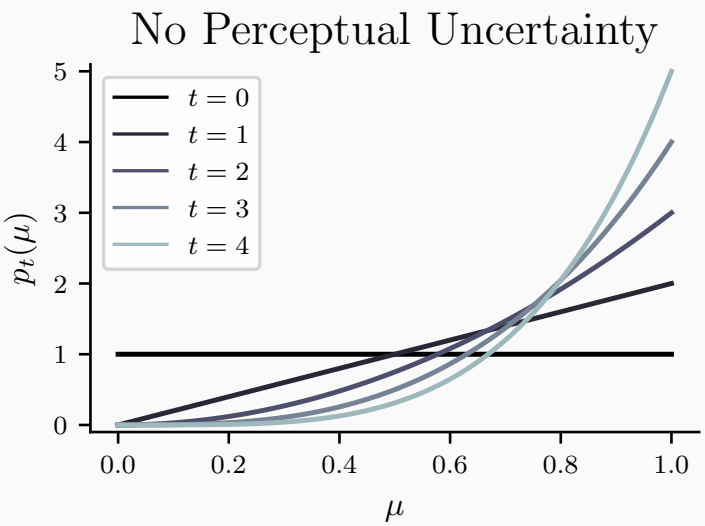
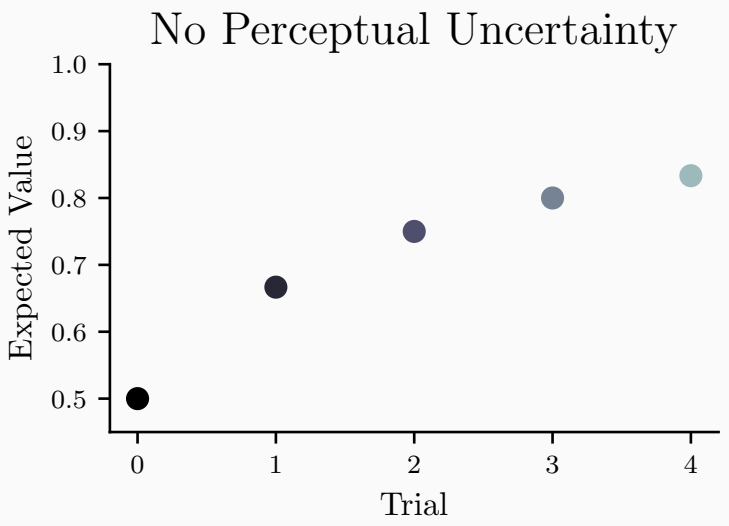
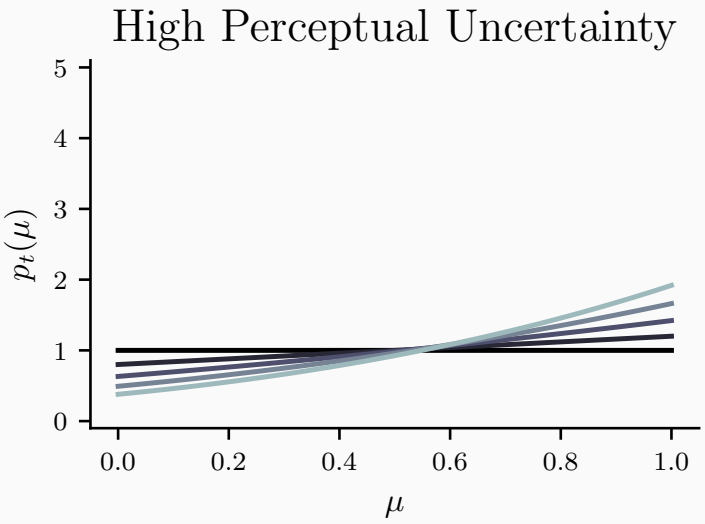
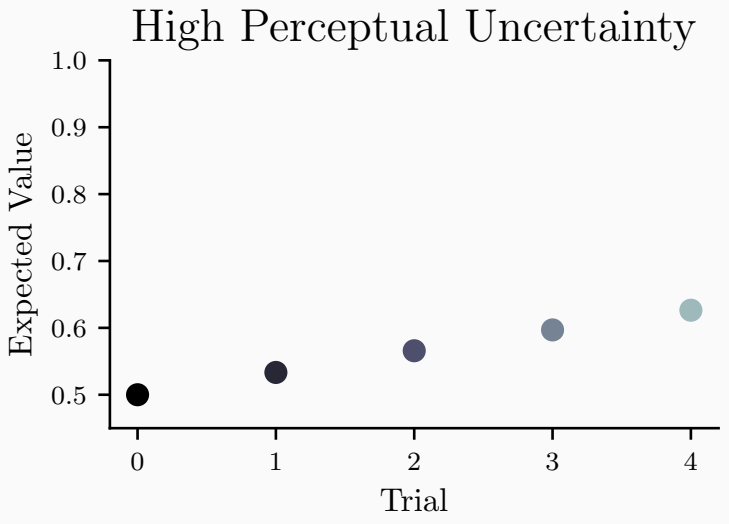
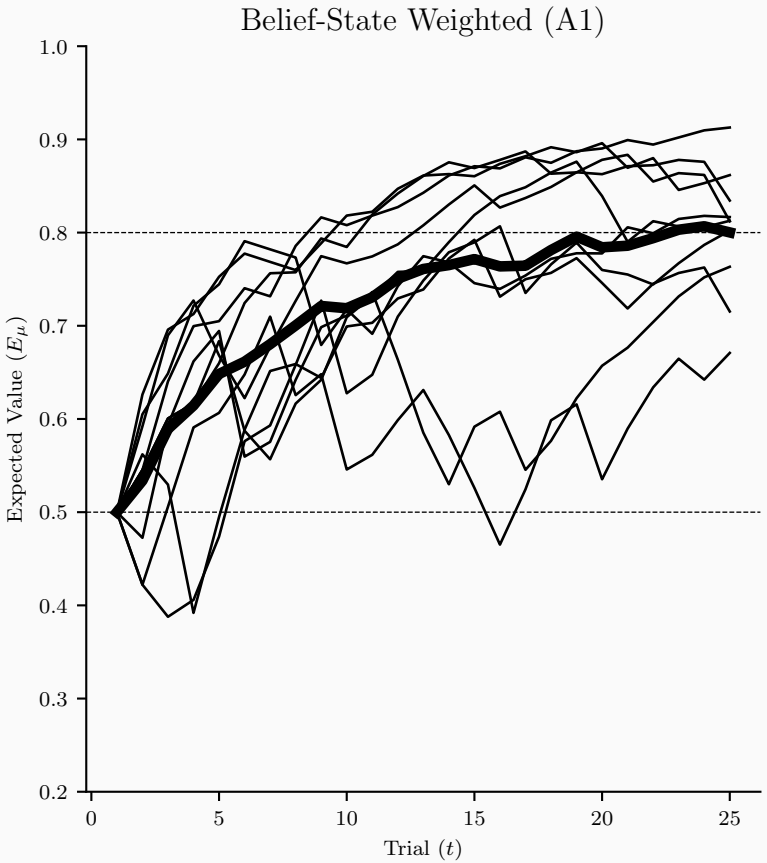




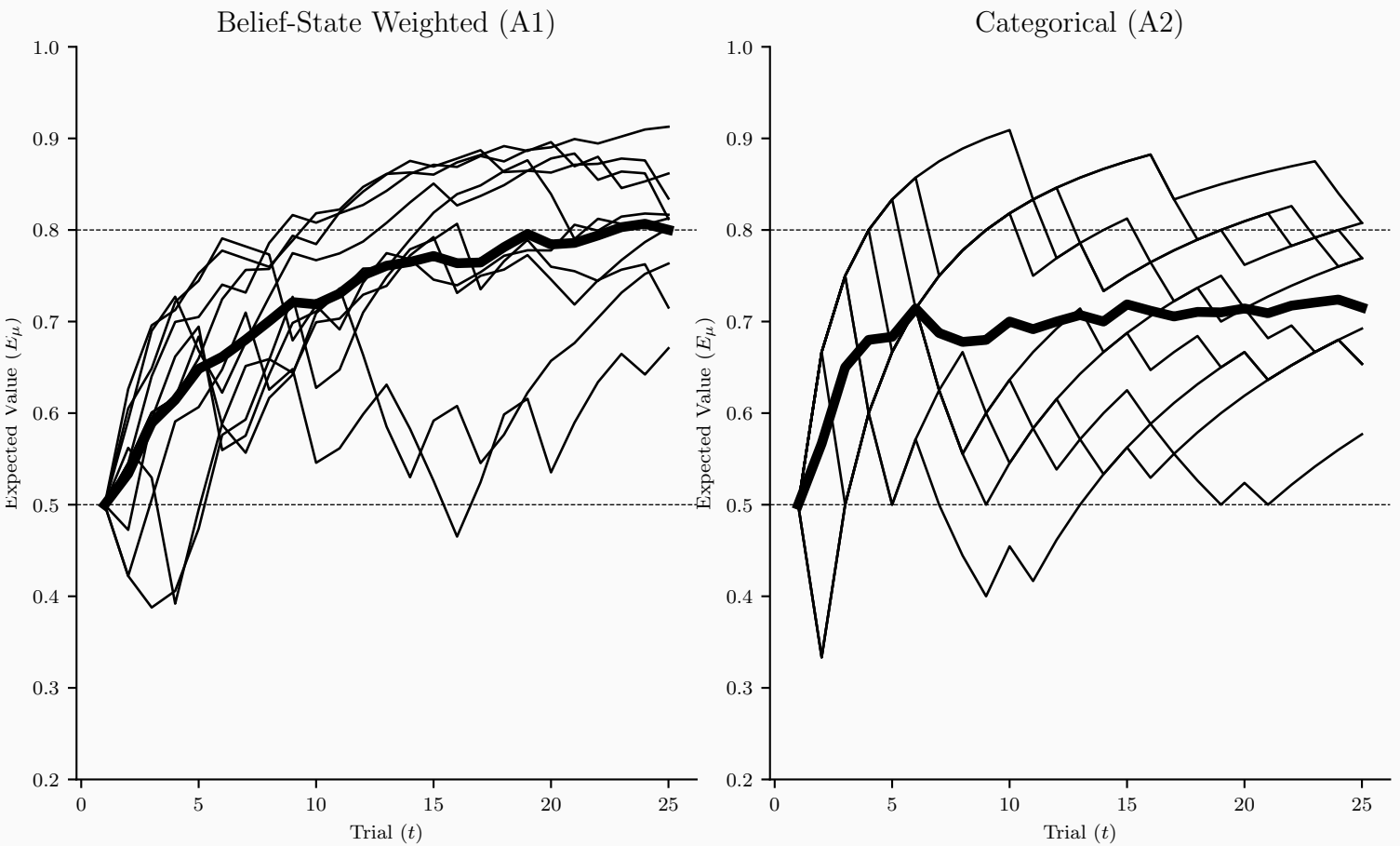




Behavioral Modelling - Performance



Behavioral Modelling - Performance



Sensory Noise - Perceptual Uncertainty Consideration Correlation