Sensory Uncertainty Influences Value-based Risky Decisions

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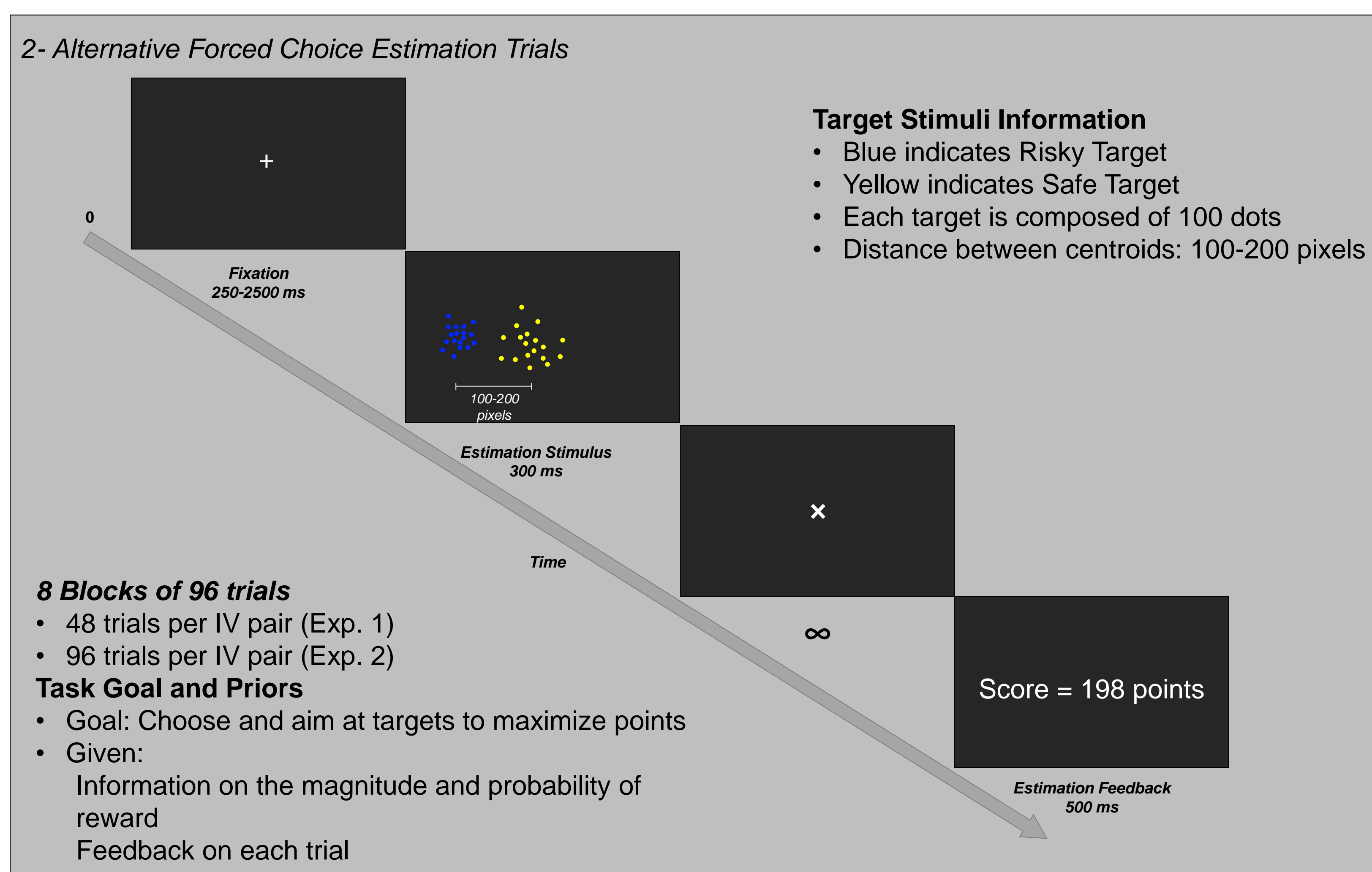
Background

When making a risky decision, humans aim to maximize expected gains. In many realistic contexts, expected gains can be functions of the sensory reliability of the stimuli being acted on.[1,2]

Hypotheses

1. Choices with greater sensory uncertainty will be less favored, while those with higher rewards relative to risk will be more favored.
2. Choices with higher reward and higher probabilities of reward will be favored over a safe alternative with high sensory uncertainty.

Methods

2- Alternative Forced Choice Estimation Trials

Target Stimuli Information
- Blue indicates Risky Target
- Yellow indicates Safe Target
- Each target is composed of 100 dots
- Distance between centroids: 100-200 pixels

8 Blocks of 96 trials
- 48 trials per IV pair (Exp. 1)
- 96 trials per IV pair (Exp. 2)

Task Goal and Priors
- Goal: Choose and aim at targets to maximize points
- Given:
  Information on the magnitude and probability of reward
  Feedback on each trial

Independent Variables

Experiment 1
- Reward & Penalty Magnitude of Risky Target
- Safe Target Spatial Variance (standard deviation of dots from the centroid)

Experiment 2
- Reward & Penalty Magnitude of Risky Target
- Risky Target Probability of Reward

Dependent Variable
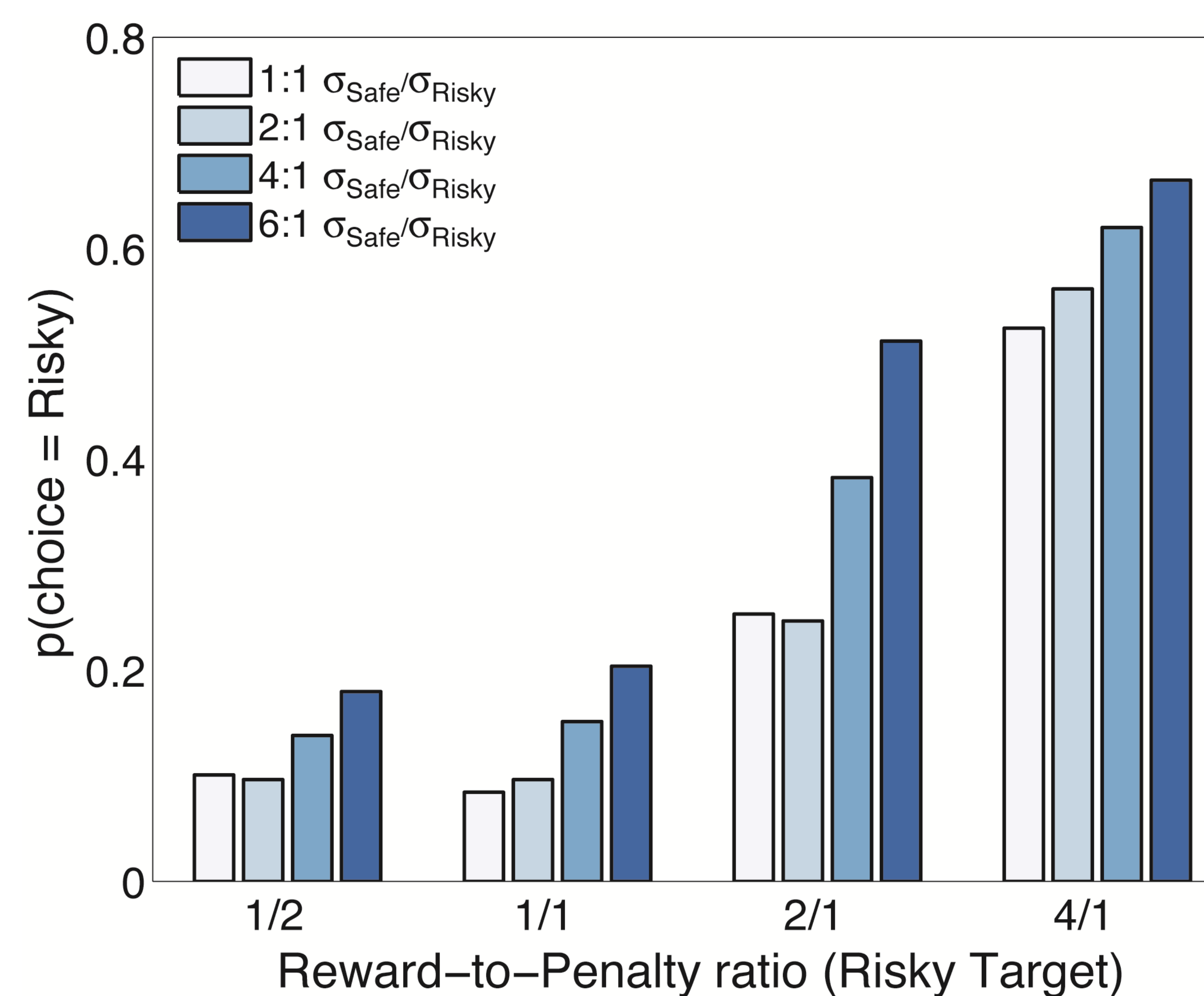- Choice preference

Participants
Pitt and CMU undergraduates
20 subjects (14 male) in Experiment 1
20 subjects (7 male) in Experiment 2
CMU IRB-approved consent

Experiment 1: Spatial variance vs reward-to-penalty ratio

	Safe Target	Risky Target
Probability of Reward	1	0.5
Probability of Punishment	0	0.5
Values (Relative to Safe Target)	1	1:-2 , 1:-1 , 2:-1 , 4:-1, by block
Target Size (Dot Variance)	$\sigma = 33*(1, 2, 4,$ or 6) pixels, by trial	$\sigma = 33$ pixels

Results

- Higher reward-to-penalty magnitude increases risky decisions ($F(3,57)=42.83$, $p<0.001$).
- Higher safe target spatial variance increases risky decisions ($F(3,57)=24.94$, $p<0.001$).
- With an interaction between the magnitude and variance ($F(9,171)=4.651$, $p<0.001$).
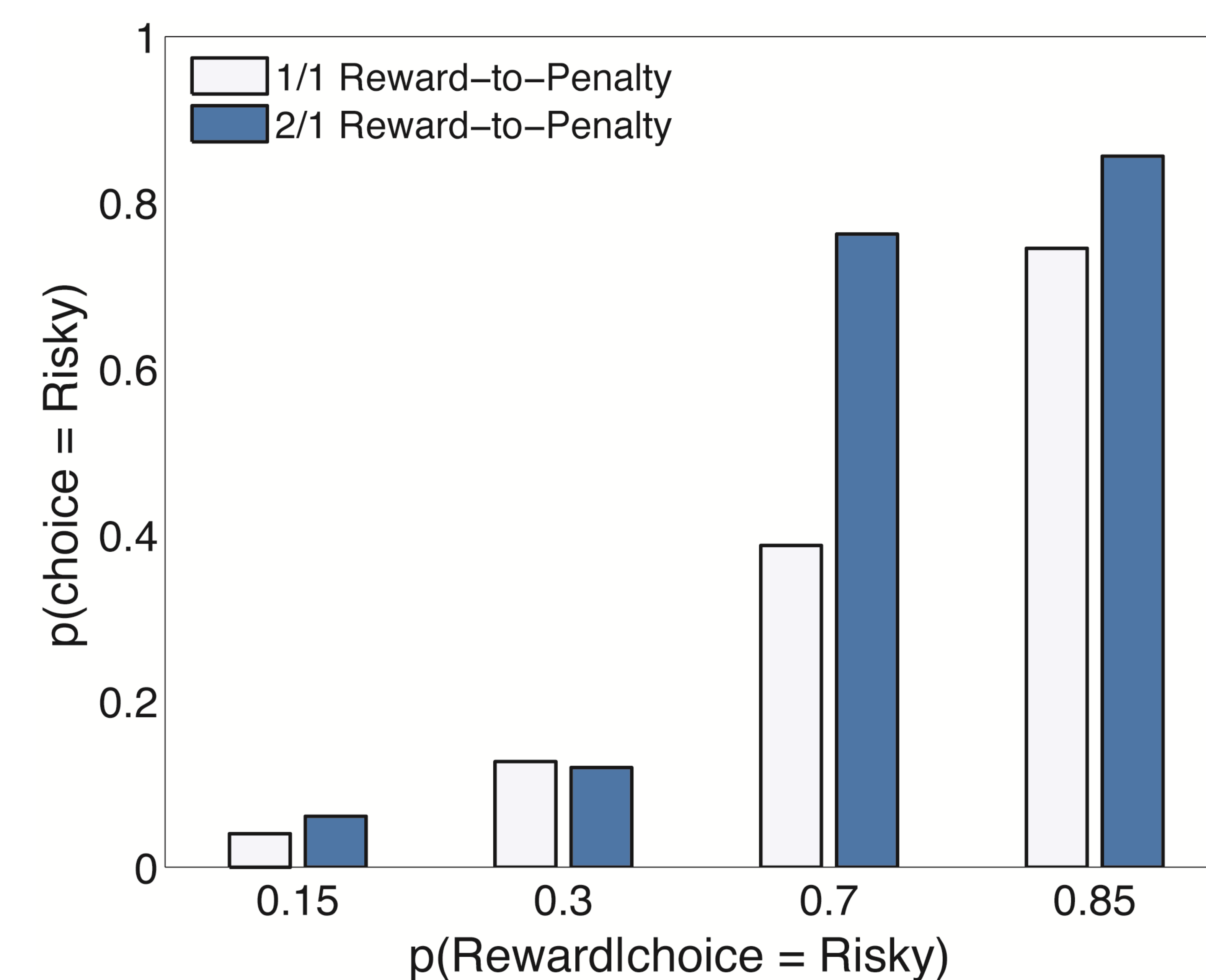

Experiment 2: Risk probability and reward in high spatial variance

	Safe Target	Risky Target
Probability of Reward	1	0.15, 0.3, 0.7, 0.85, by block
Probability of Punishment	0	1 − p(Reward)
Values (Relative to Safe Target)	100	1:-1 , 2:-1, by block
Target Size (Dot Variance)	$\sigma = 132$ pixels	$\sigma = 33$ pixels

Results

- Higher reward-to-penalty magnitude increases risky decisions ($F(1,19)=16.54$, $p<0.001$)
- Higher reward probability increases risky decisions ($F(3,57)=79.43$, $p<0.001$).
- With an interaction between probability and magnitude ($F(3,57)=4.194$, $p<0.01$).

Summary

1. Reward and penalty magnitudes cause preference to shift towards a stimulus while spatial uncertainty causes preference to shift towards a riskier alternative.
2. Higher probabilities of reward increase preference for a risky target relative to a spatially uncertain alternative.

Conclusion

Humans make riskier decisions not only when they have a higher probability and magnitude of reward, but also when the alternative is more spatially uncertain.

References

[1] Jarbo, K., Flemming, R., and Verstynen, T. 2016. "Feedback Learning Competes with Perceptual Bias during Risky Spatial Decisions." submitted.

[2] Trommershäuser, Julia, Laurence, T. Maloney, and Michael, S. Landy. 2003. "Statistical Decision Theory and the Selection of Rapid, Goal-Directed Movements." *Journal of the Optical Society of America. A, Optics, Image Science, and Vision* 20 (7): 1419–33.

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