Real-time inference of physical properties in dynamic scenes

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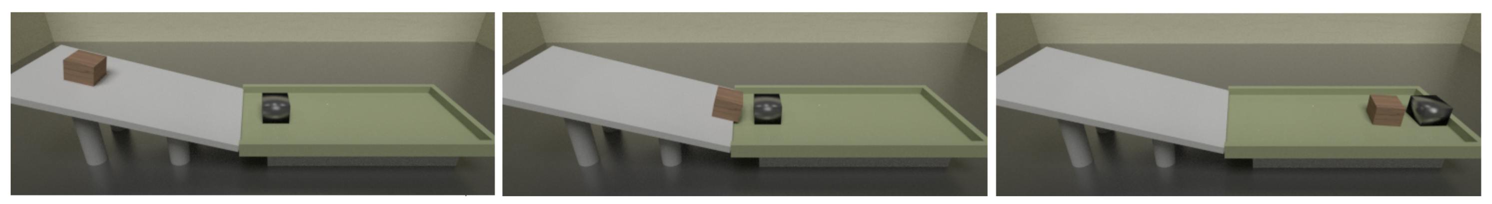
Motivation

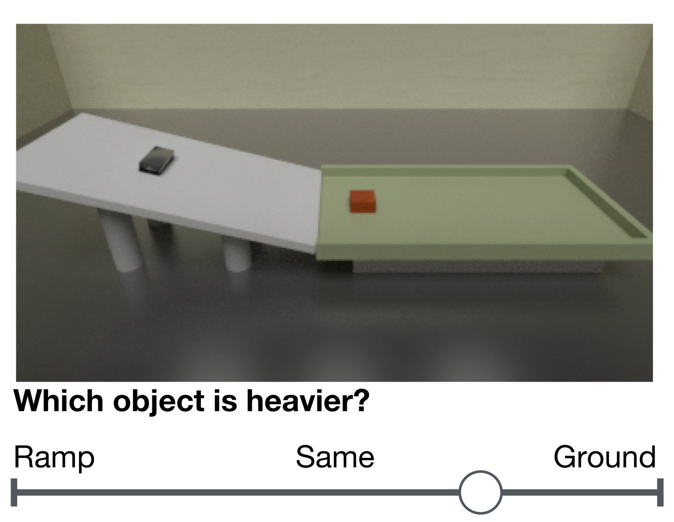
- Human scene understanding involves inferring latent causal properties – e.g., objects' mass
- These properties can be inferred in real-time from (1) texture, (2) object dynamics
- How do we do this "online" updating?
- Test via incongruencies in texture, dynamics



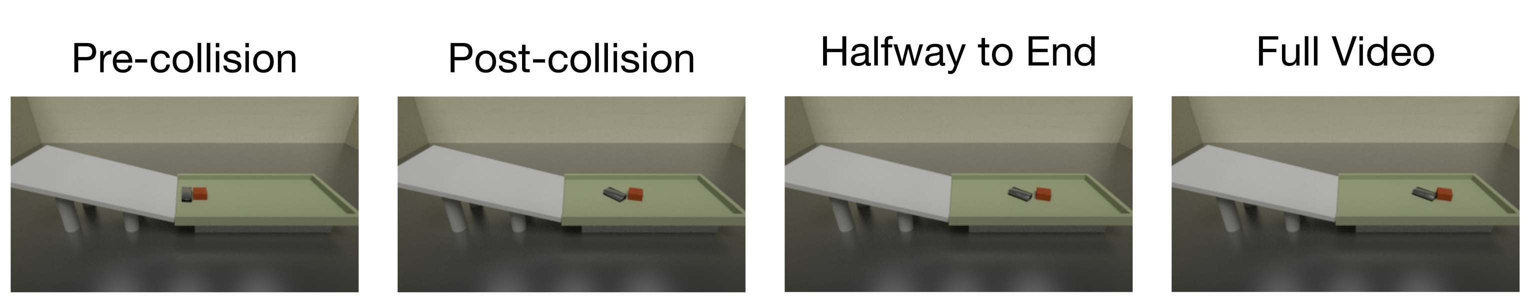
Experiment

Task

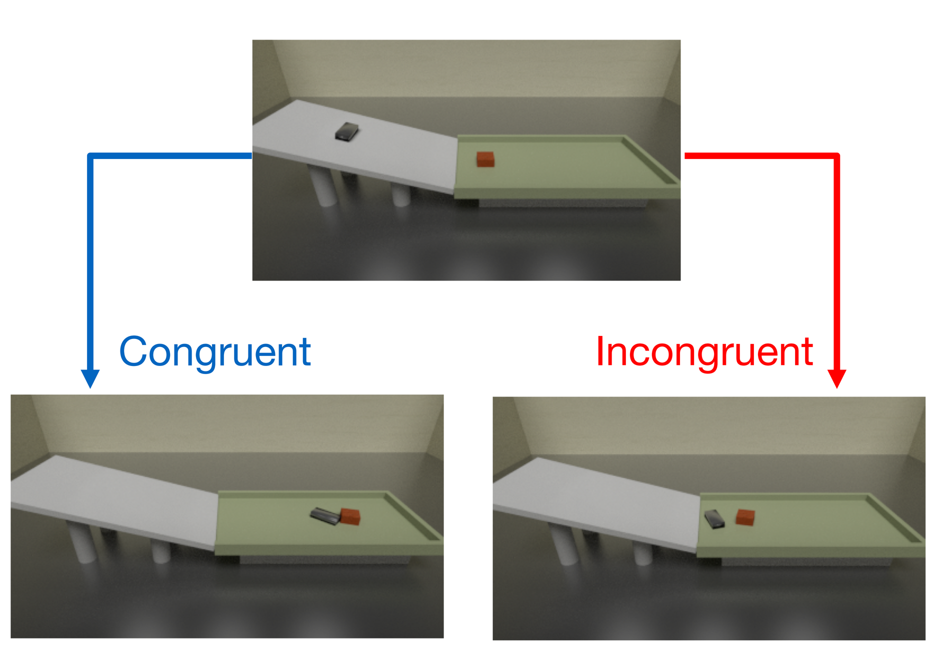
- Watch videos of dynamic collisions
- Judge relative masses



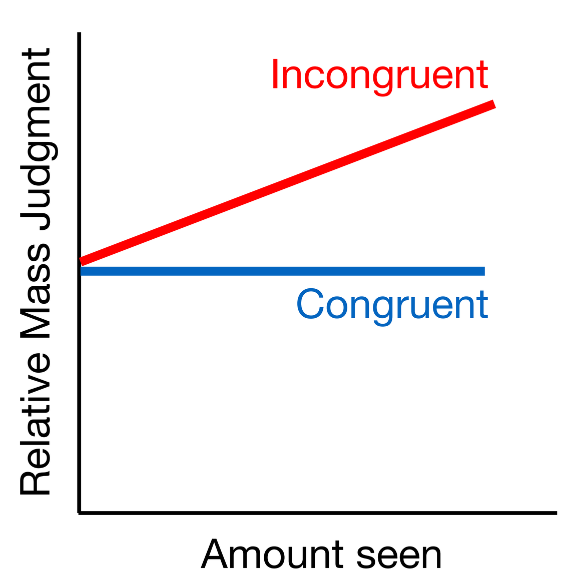
Four video cuts / scene



20% "incongruent" scenes



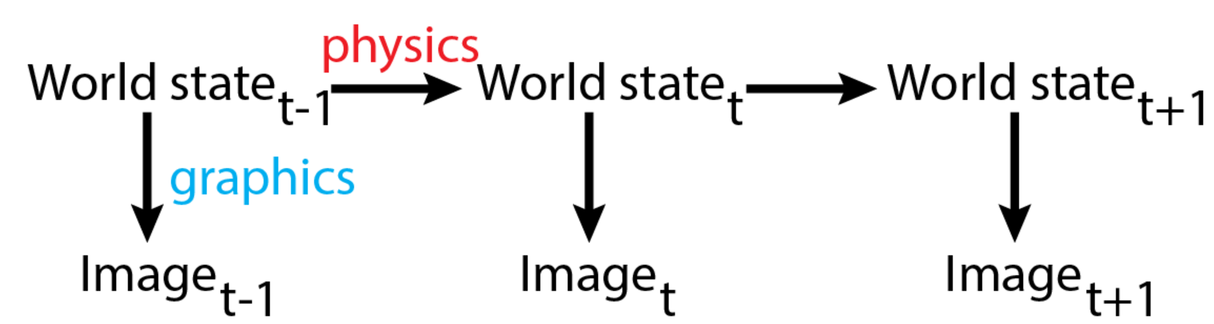
Hypothesis:



Dynamic Physical Inference

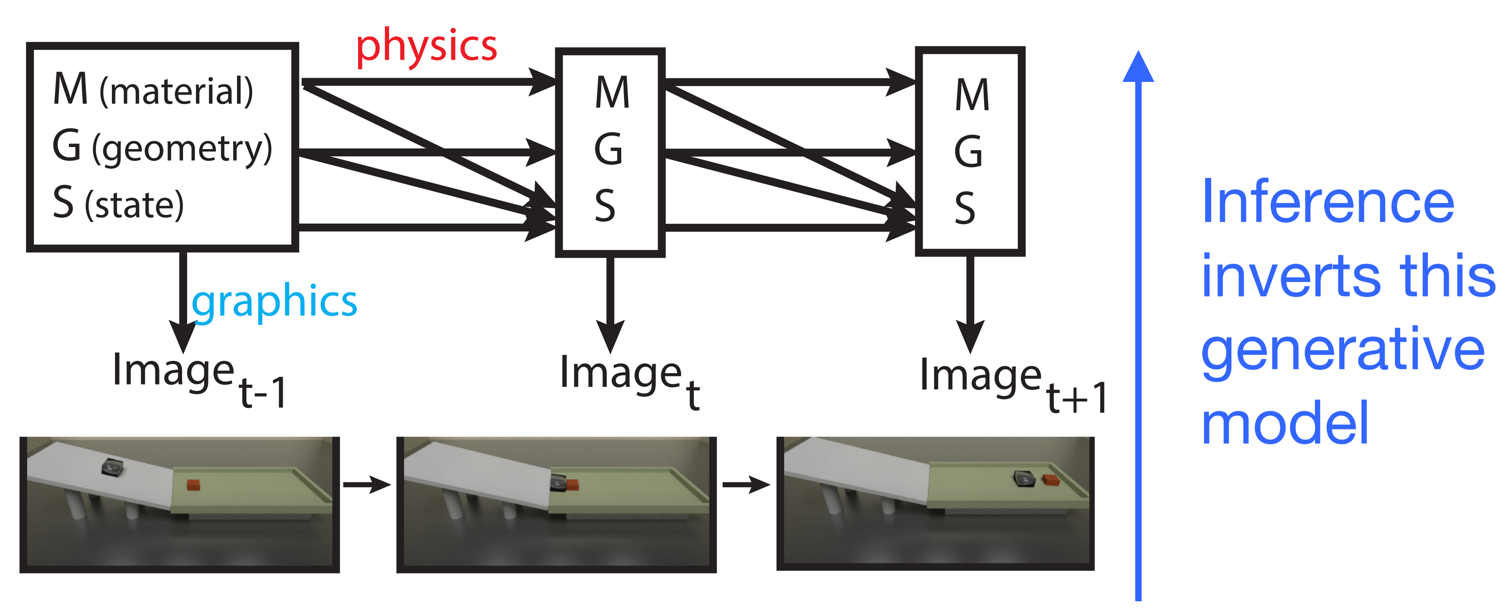
"Analysis by Synthesis:" reconstructing the scene that gives rise to sense inputs

Generative model



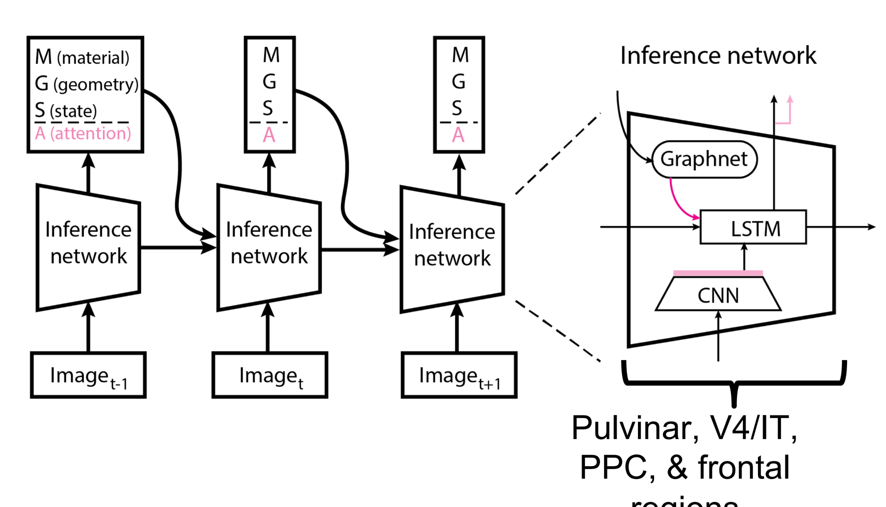
Battaglia, Hamrick, Tenenbaum (2013)

Inference problem

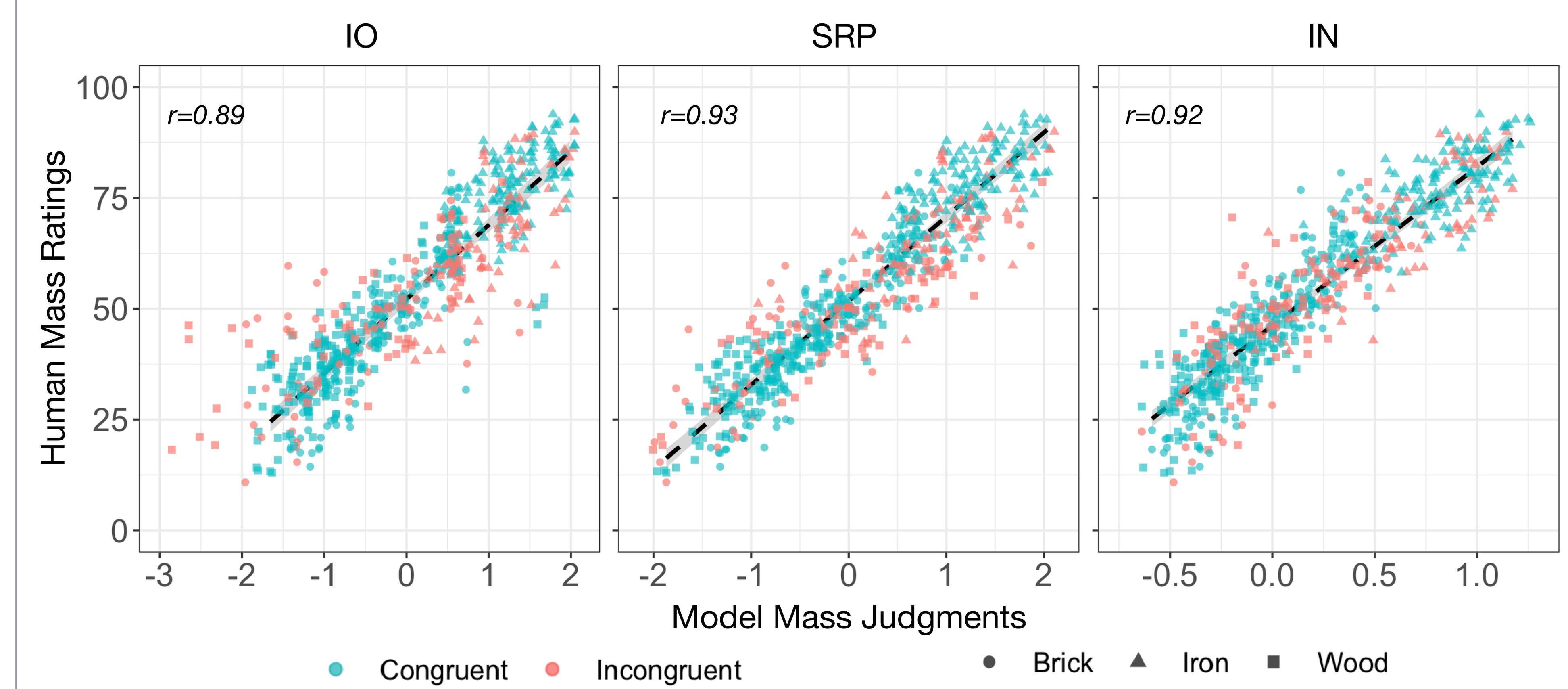


Inference Models

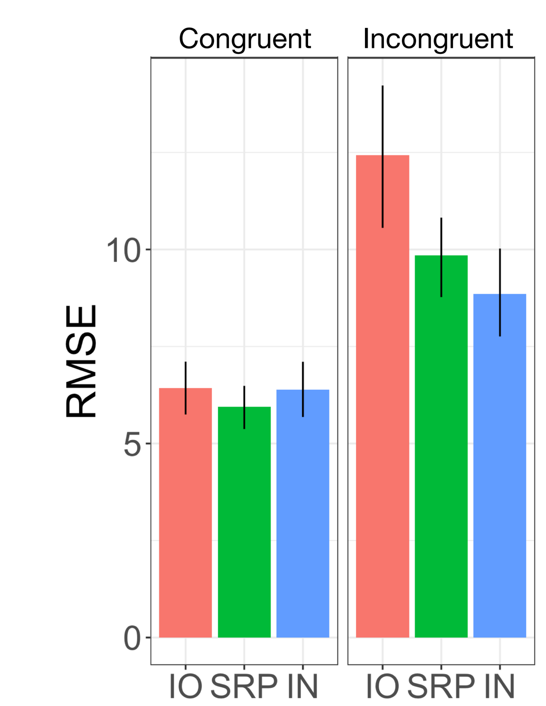
1. **Ideal Observer**
   - Exact inference at each time point
2. **Sequential Rational Process**
   - Approximation using Particle Filters
   - Resource constrained: 4 hypotheses at a time
3. **Inference Network**
   - Learns approximate inverse function
   - Plausible neural mapping?

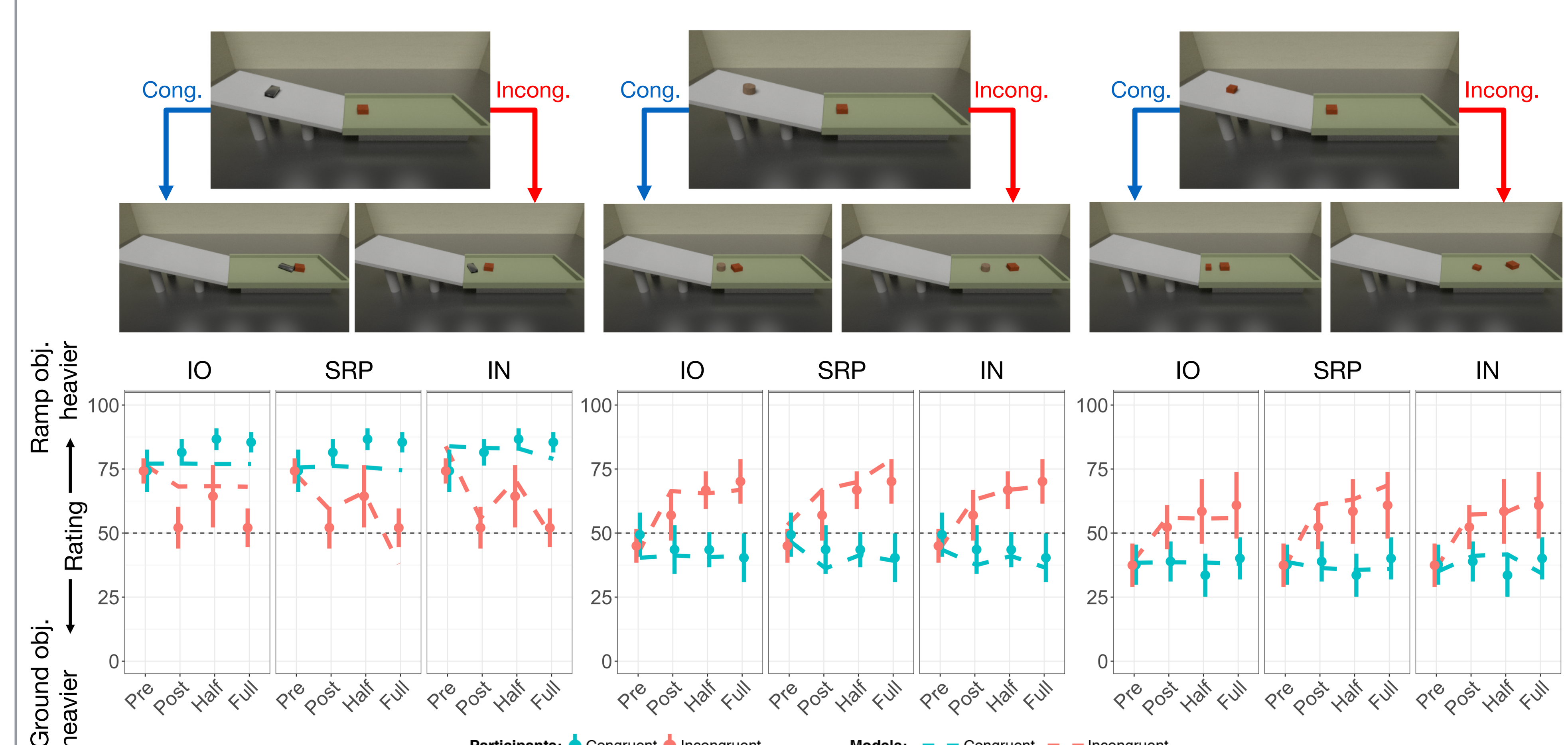


Results



- All models explain human judgments well overall
- But fit in IO is driven by congruent trials, whereas approximate models extend well to incongruent
- Approximate models capture dynamics of human judgment over time





Discussion

- Bayesian inference provides rich, causal explanations of sensory inputs supporting physical scene understanding
- Dynamic inference driven by efficient, approximate algorithms
- IN provides starting point for understanding physical inference in the brain

Acknowledgments

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