

Rapid Physical Predictions from Convolutional Neural Networks



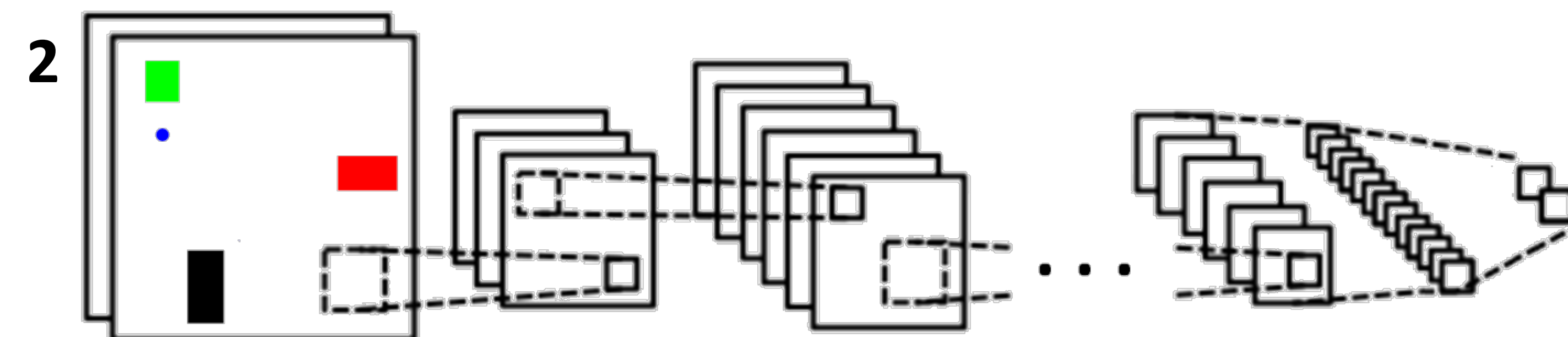
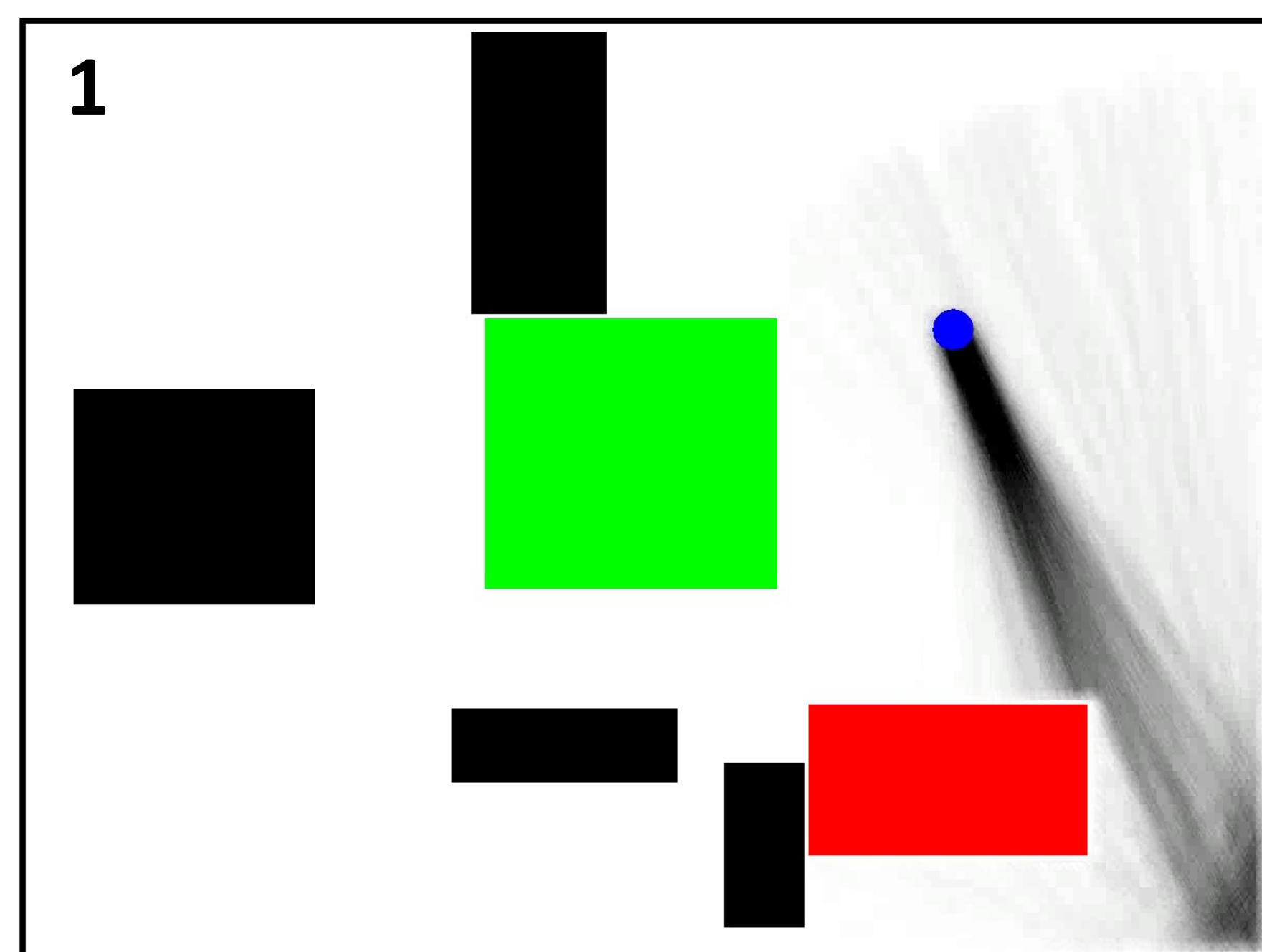
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Introduction

- Physical prediction can be explained by probabilistic simulation using an “intuitive physics engine” [1]
- Simulations are general-purpose yet computationally costly, so quick decisions may be based on heuristics
- Can we capture heuristics for physics prediction with CNNs?
- If so, what heuristics are learned and when do people use them?

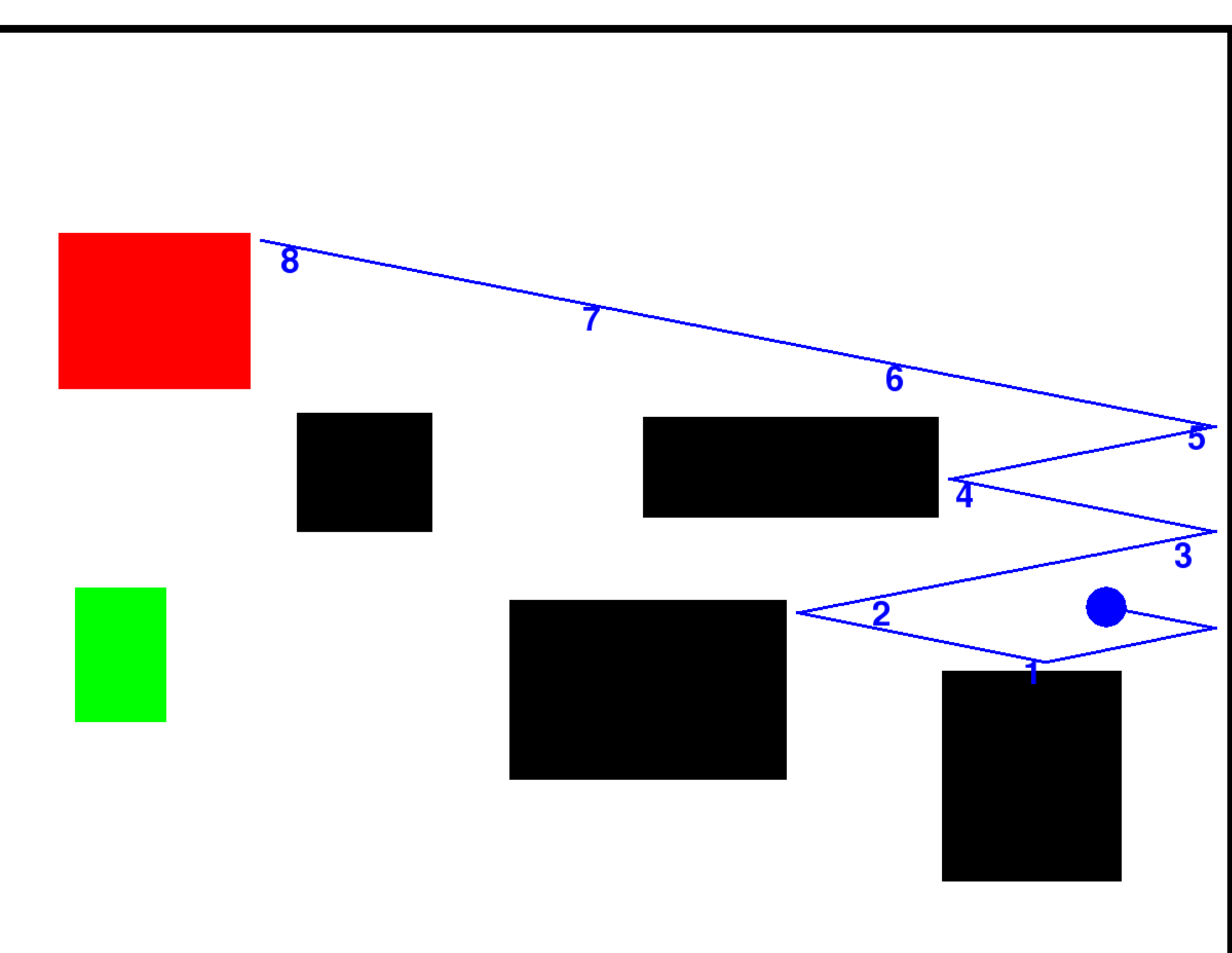
Models



Models to compare

- Simulation-based physics model accumulates evidence from noisy simulation [2]
- Modified GoogLeNet [3] predicts red/green probability from 2 input frames (based on ~1M training examples)

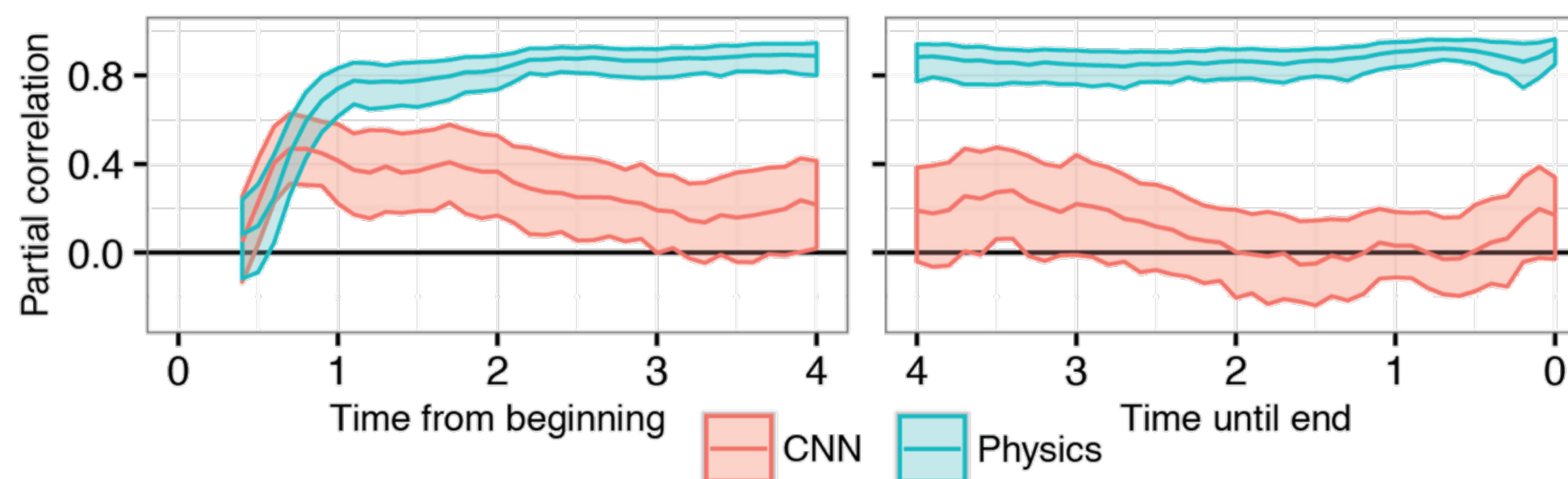
Task



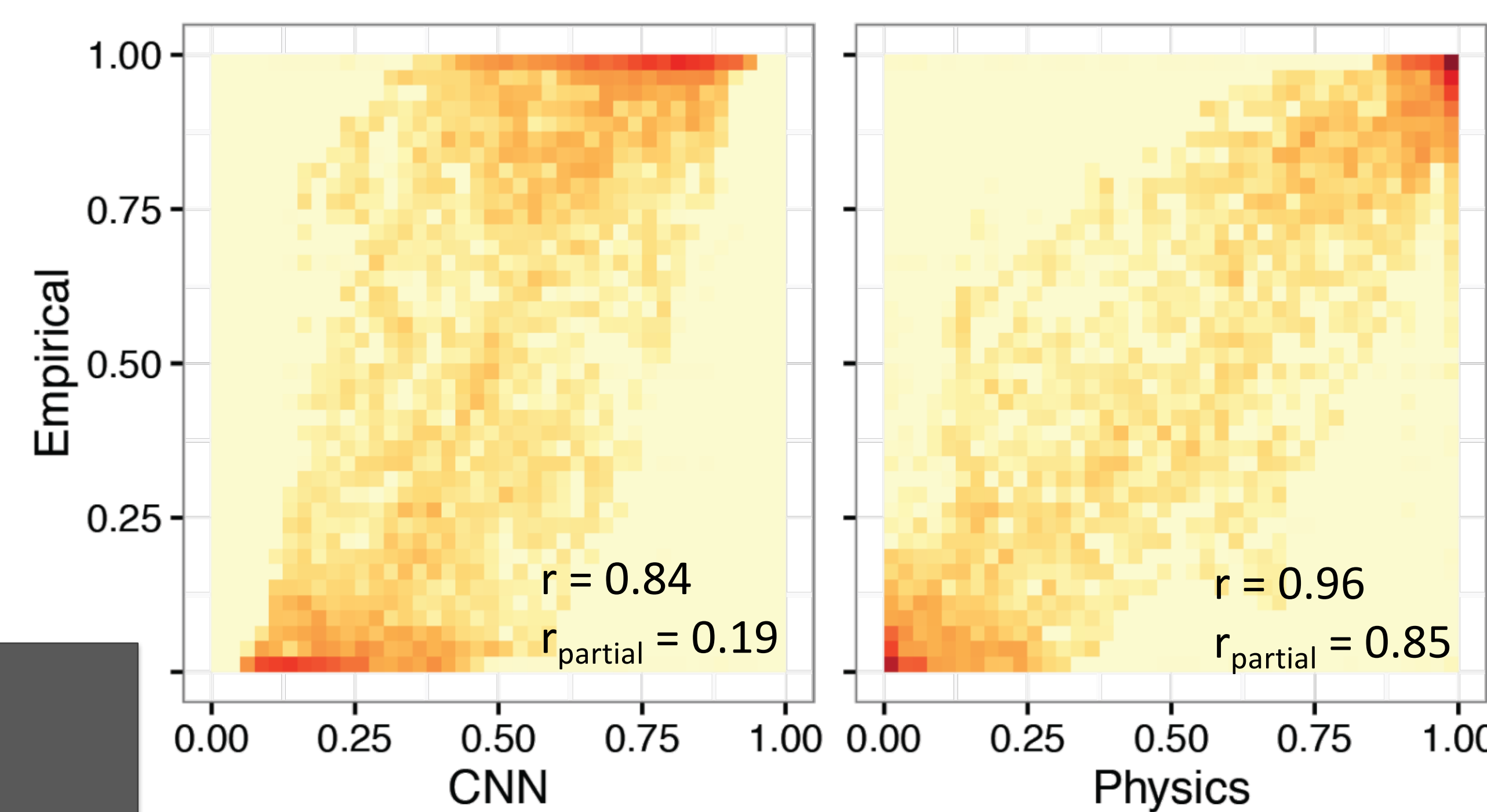
- Continuous prediction of goal the ball will reach first
- Responses aggregated: what proportion of participants predicted red vs. green every 100ms?

Results

Partial correlations (excl. other model) at each trial step



Correlation between CNN/Physics and Humans



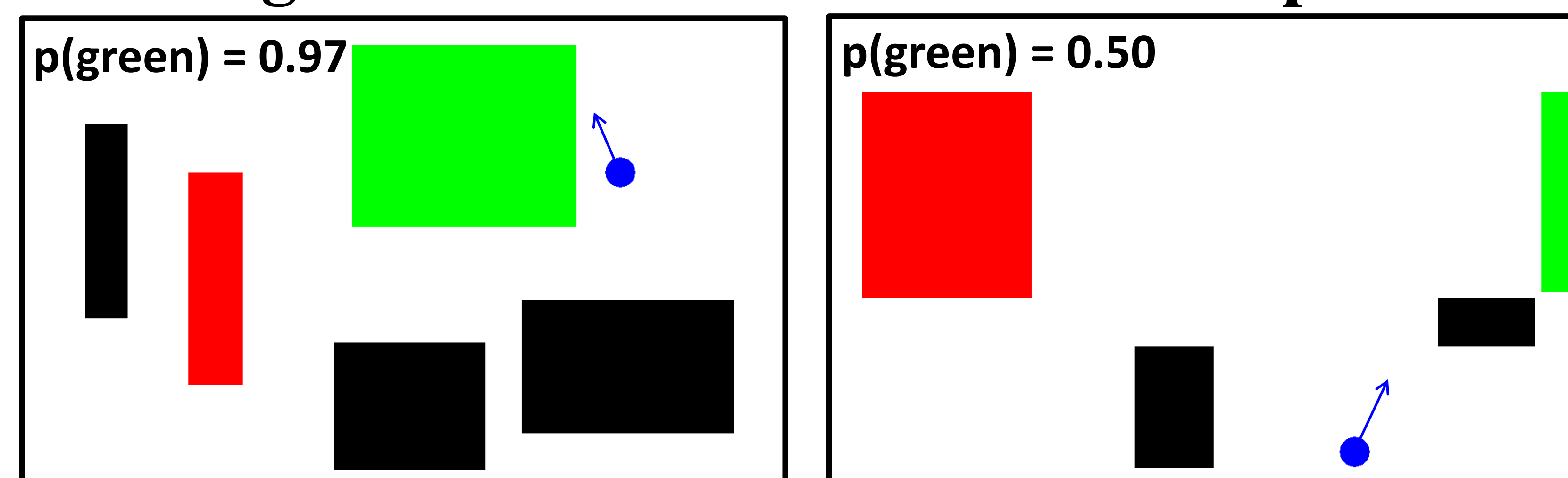
Correlation between CNN and trial features

Heuristic	Correct Goal	Other Goal
Distance to Goal	-0.650	0.503
Wall Between	-0.323	0.110
Heading Offset	0.001	-0.042
Goal Area	0.109	0.079

Discussion

- CNN explains human some predictions, but not as well as noisy physical simulation
- Predictive power of CNN is strongest in initial seconds – suggests it may capture quick impressions over simulation
- CNN predictions best described using heuristics and statistical regularities
- Human physical prediction may initially rely on quick heuristics, then later on rich physical simulation

High and low confidence trial samples



References

- [1] Battaglia, P. W., Hamrick, J. B., and Tenenbaum, J. B. *Simulation as an engine of physical scene understanding*, 2013.
- [2] Smith, K. A., Dechter, E., Tenenbaum, J. B., and Vul, E. *Physical predictions over time*, 2013.
- [3] Szegedy, C., Liu, W., Jia, Y., Sermanet, P., Reed, S., Anguelov, D., Erhan, D., Vanhoucke, V., and Rabinovich, A. *Going Deeper With Convolutions*, 2015.