Inferring Knowledge from Behavior in Search-and-rescue Tasks

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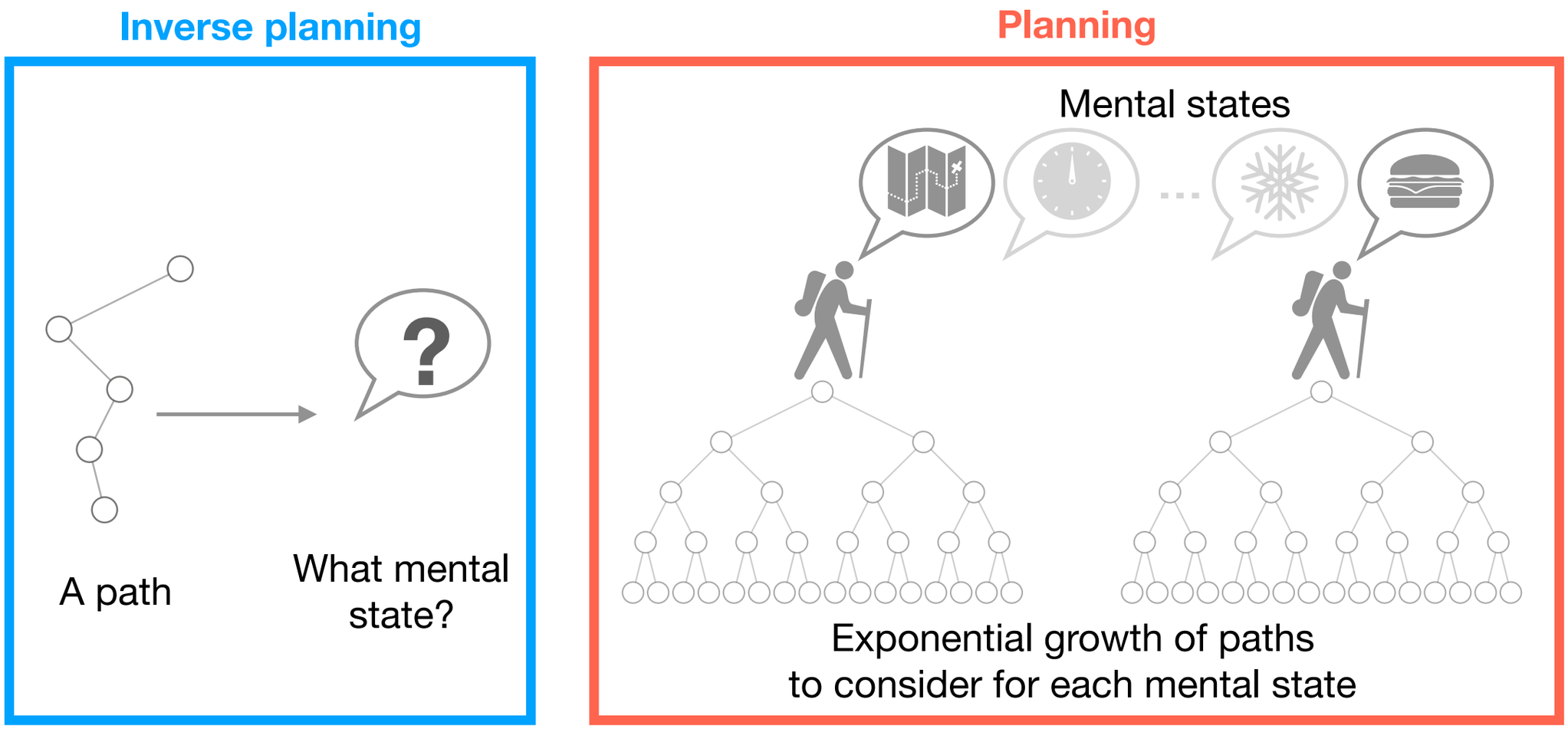
Introduction: Theory-of-mind inference as inverse planning

General problem: Theory-of-mind inference is natural for humans but poses significant computational challenges.



Approach: abstraction + myopic rational agent analysis

Baker, C. L., Saxe, R., & Tenenbaum, J. B. (2009). Action understanding as inverse planning. Cognition, 113(3), 329– 349.

Experiment: Search-and-rescue task in Minecraft

- Each participant engaged in a single-person, first-person-view, search-and-rescue task.

Huang, L., Freeman, J., Cooke, N., et al. (2021). Using humans' theory of mind to study artificial social intelligence in Minecraft search and rescue. Technical report.

Setting: Search-and-rescue task in Minecraft

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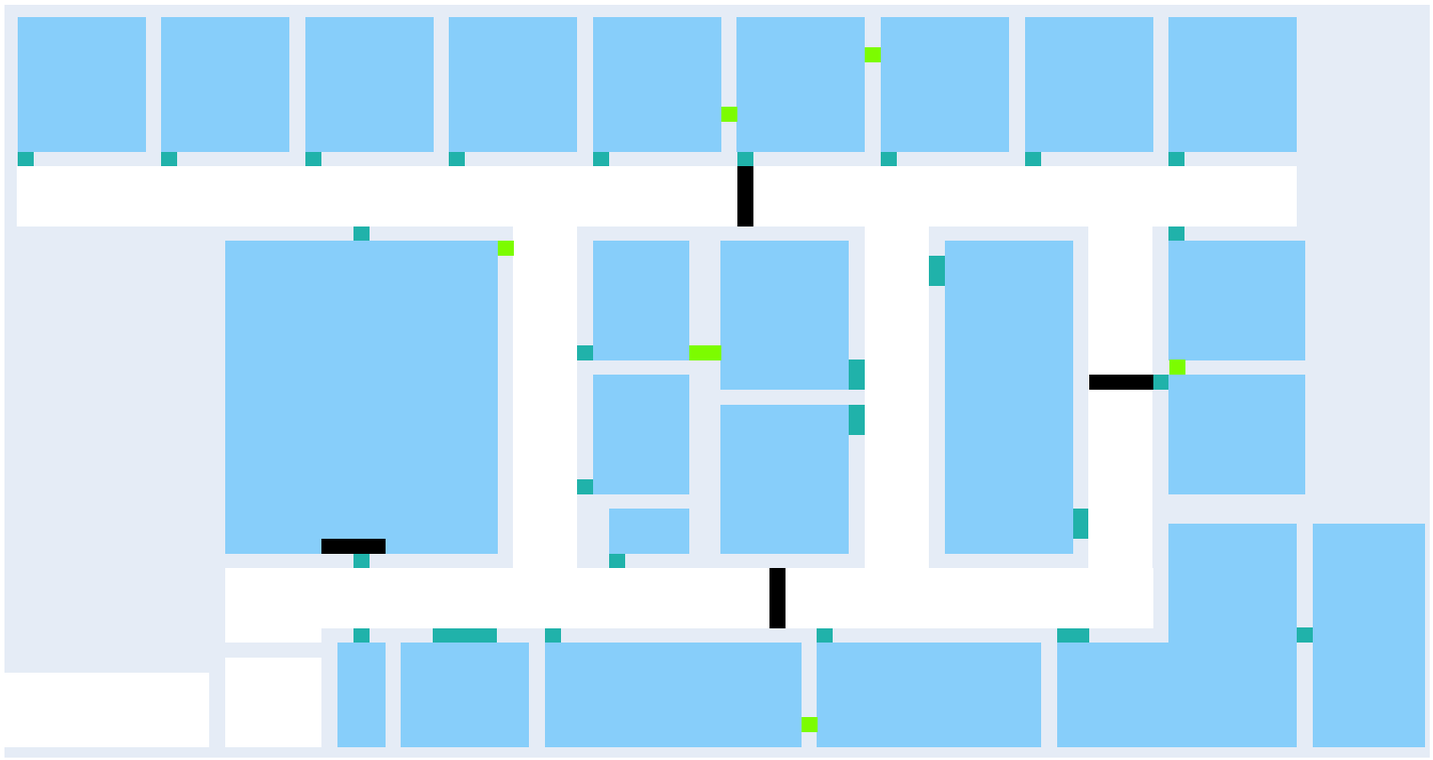
- The environment was a collapsed office building consisting of rooms and corridors.



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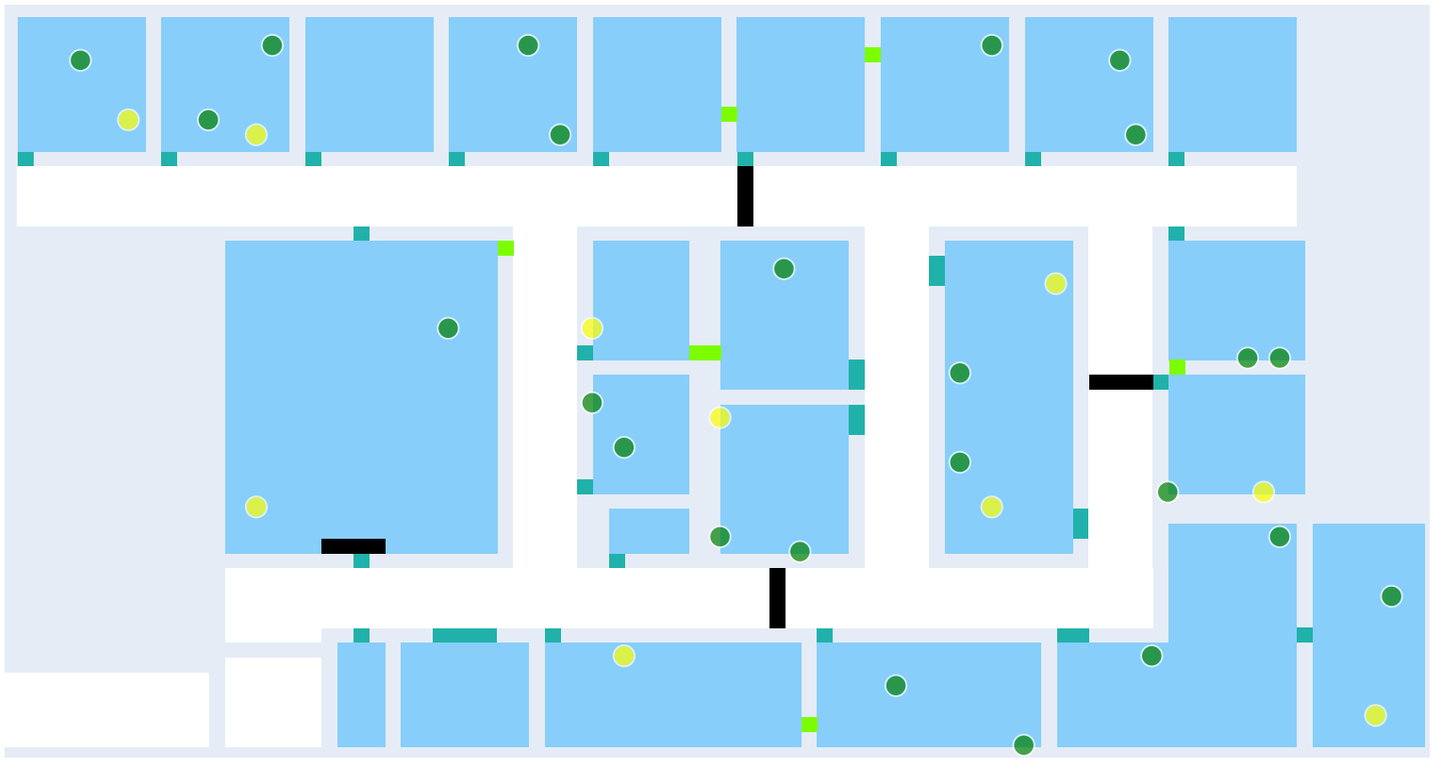

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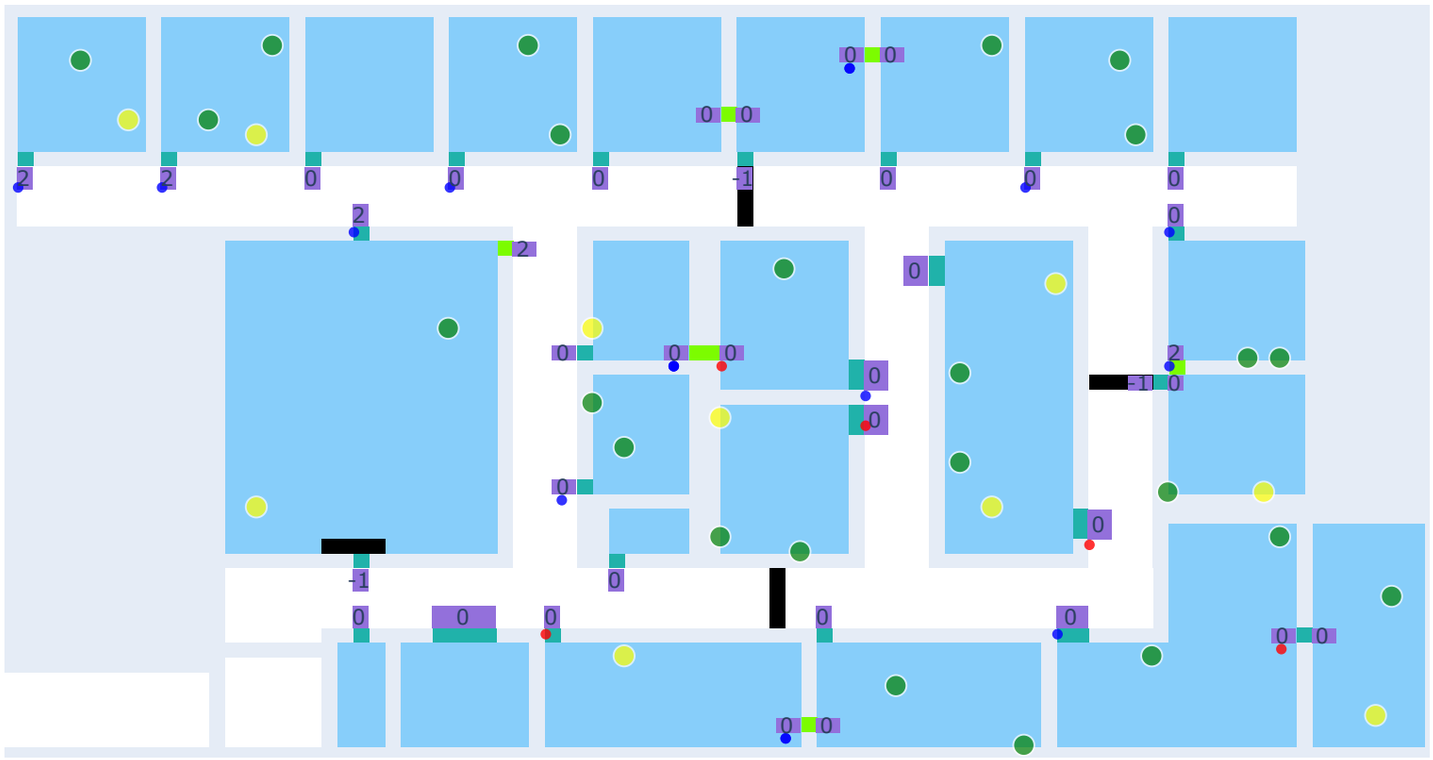

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- Rescue device
  knowledge condition:
  signal (18); **no signal** (36)

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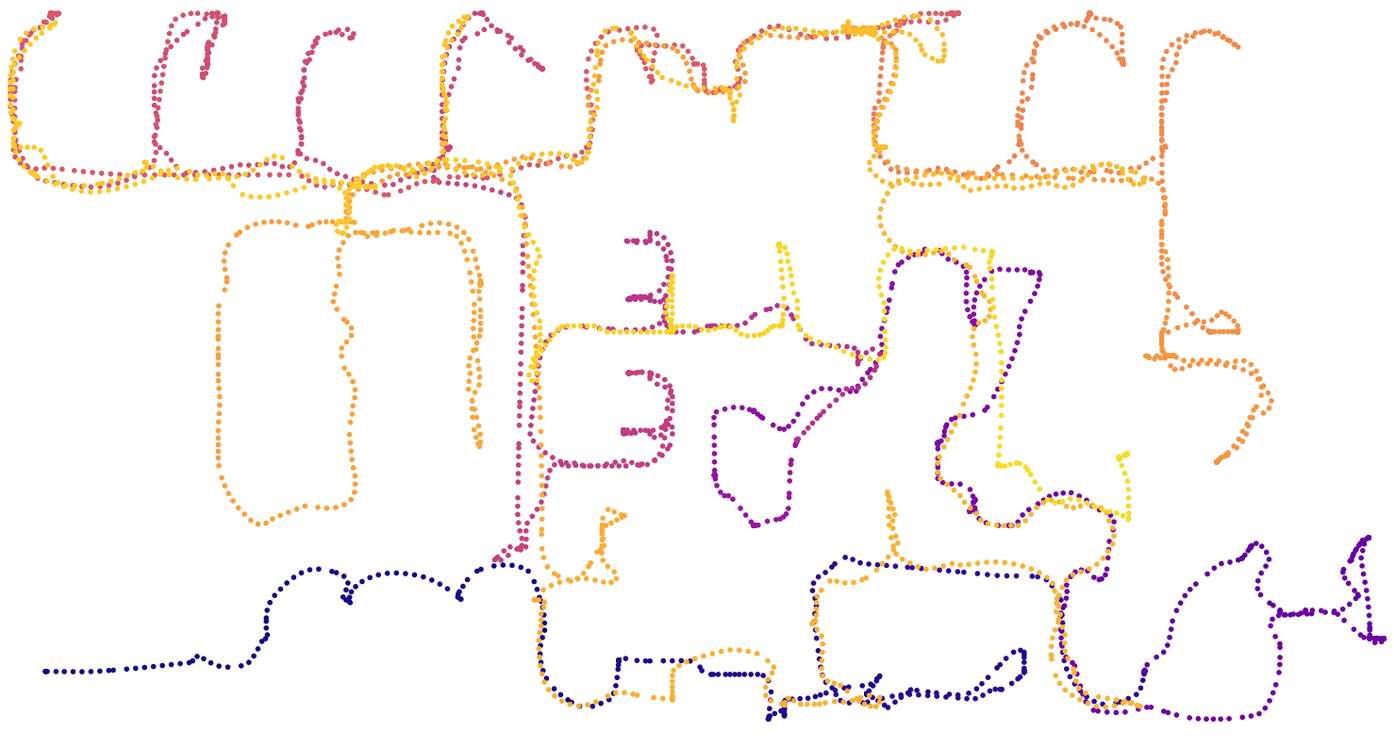

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- **Can we infer knowledge condition from the trajectory?**

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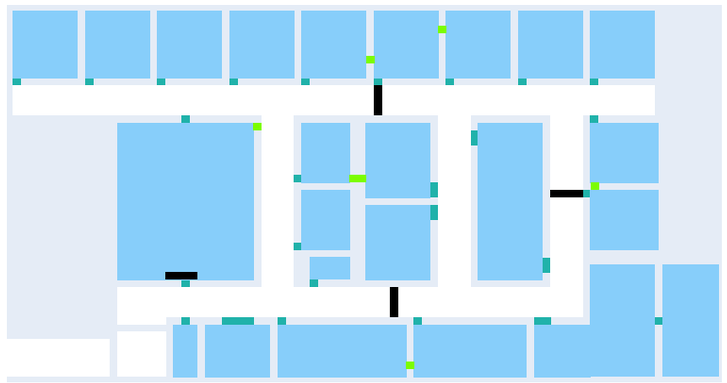
Abstraction

Typical

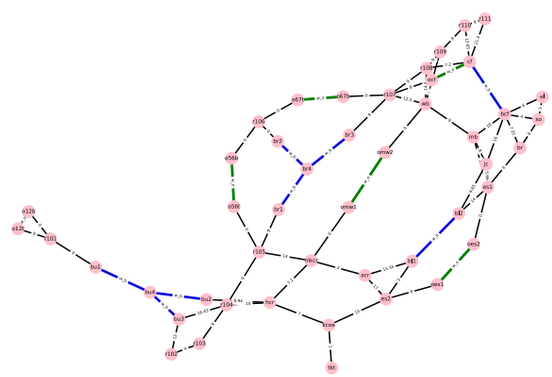
Abstracted

Spatial states



geometry

topology



Reward function

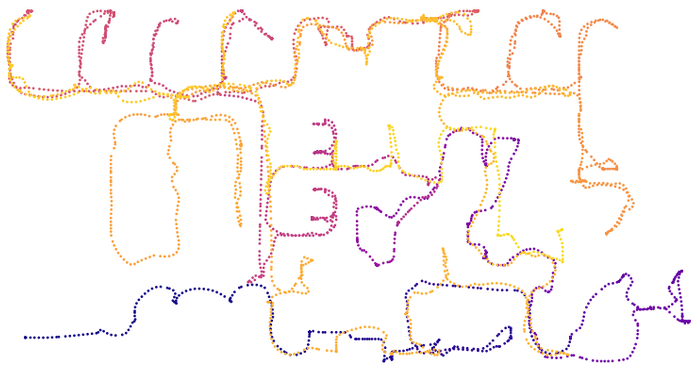
10	-1	-1	-1	x	-1
-1	-1	-1	-1	x	-1
-1	-1	-1	-1	-1	-1
-1	5	-1	-1	x	-1
x	x	x	x	x	-1
-1	-1	-1	-1	-1	-1

value

myopia

Room-based utility ≈
Expected points /
(travel time + total triage time)

Temporal states



continuous

discrete

Decision points: room exists
Decision: next room selected

Rational agent analysis

- **Rational agents:**
  - 2 models: with **signal** knowledge; with **no signal** knowledge
  - Given: a decision point & all information gathered so far
  - Compute: the utility of each room → probabilities on room choices

- **Analysis of human data:**
  - Extract all decision points (room exists) from trajectories
  - Extract the decision (room visited next) at decision points
  - Compare the player's choice with the two rational agents' probabilistic choices

- **Result:** Yes, we can infer knowledge condition from trajectories!

Truth \ Inference	No signal	Signal
No signal (36)	0.611 (22)	0.389 (14)
Signal (18)	0.278 (5)	0.722 (13)

Please see poster 2024 for more modeling detail and results.