A model of planning in human complex problem solving

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Goal

Understand how people form plans when solving complex problems

1. By only looking at behavior (no introspection or verbal reporting)
2. Using a computational, psychologically plausible model

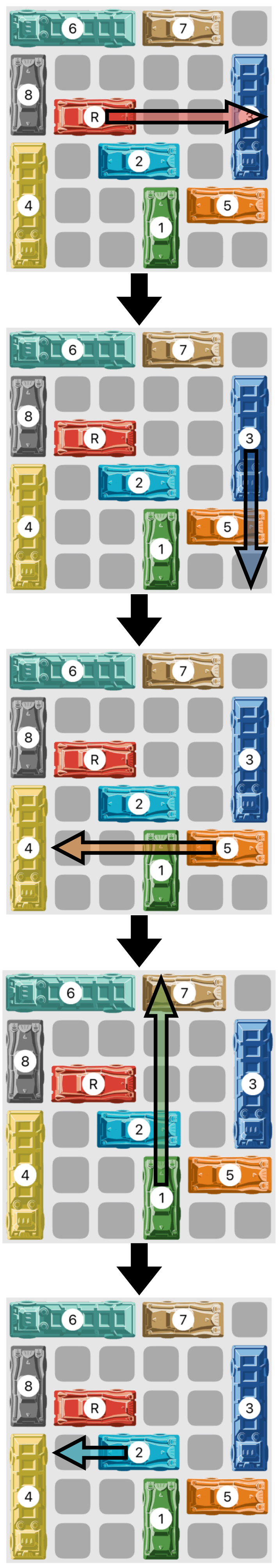
Task

Requirements:

- Need to plan multiple steps ahead
- Computationally tractable
- Minimal perceptual effects
- Minimal social component
- Fun

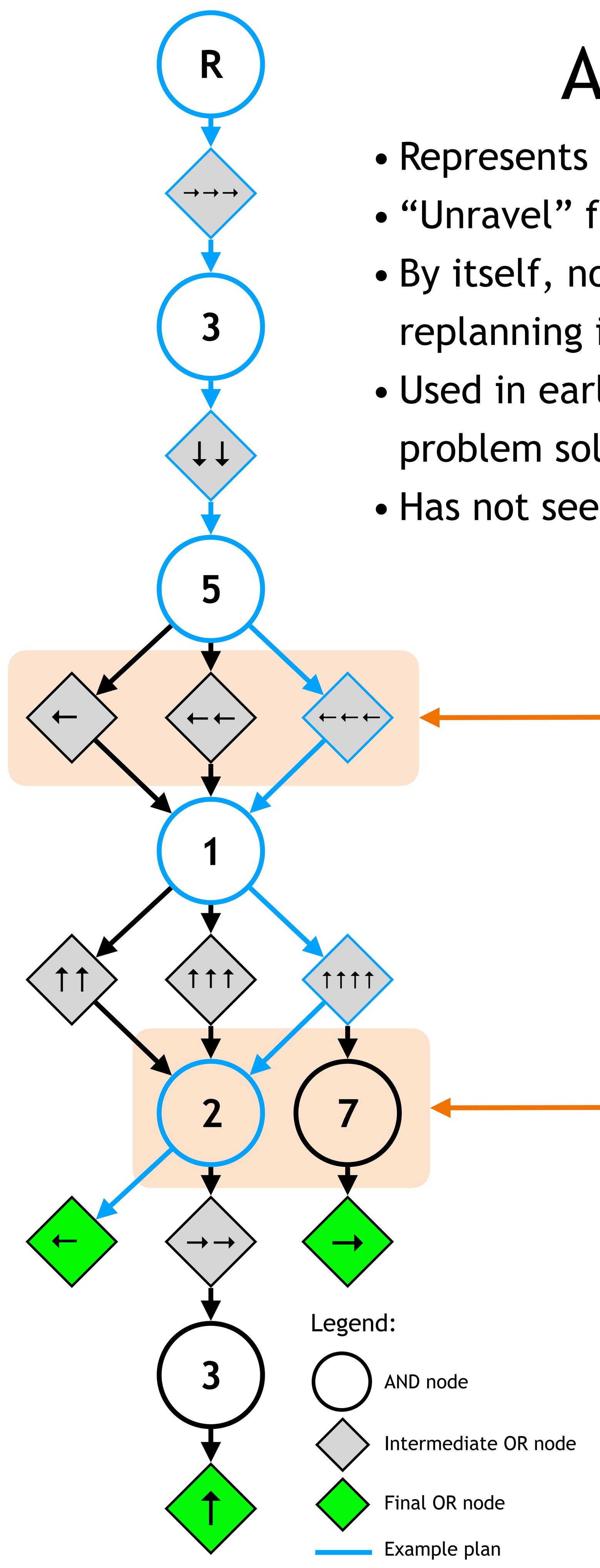
} Rush Hour [1-3]

Model



1. Find move that solves puzzle: this is the **goal**
2. Find blocking cars: move 3 out of the way
3. Find unblocking move: 3↓↓
4. Find blocking cars: move 5 out of the way
5. Find unblocking move: 5←←←
6. Find blocking cars: move 1 out of the way
7. Find unblocking move: 1↑↑↑↑
8. Find blocking cars: move 2 out of the way
9. Find unblocking move: 2←
10. Find blocking cars: no blocking cars

Representation



AND-OR tree

- Represents all possible plans the model could propose
- "Unravel" from bottom up to find plans
- By itself, not sufficient to guarantee a solution, replanning is almost always necessary
- Used in early AI development to create automated problem solvers [4-5]
- Has not seen any use in cognitive science

OR nodes

- Decisions
- Represent moves that unblock the parent car
- Each node unblocks the parent
- Subject plans along one of these

AND nodes

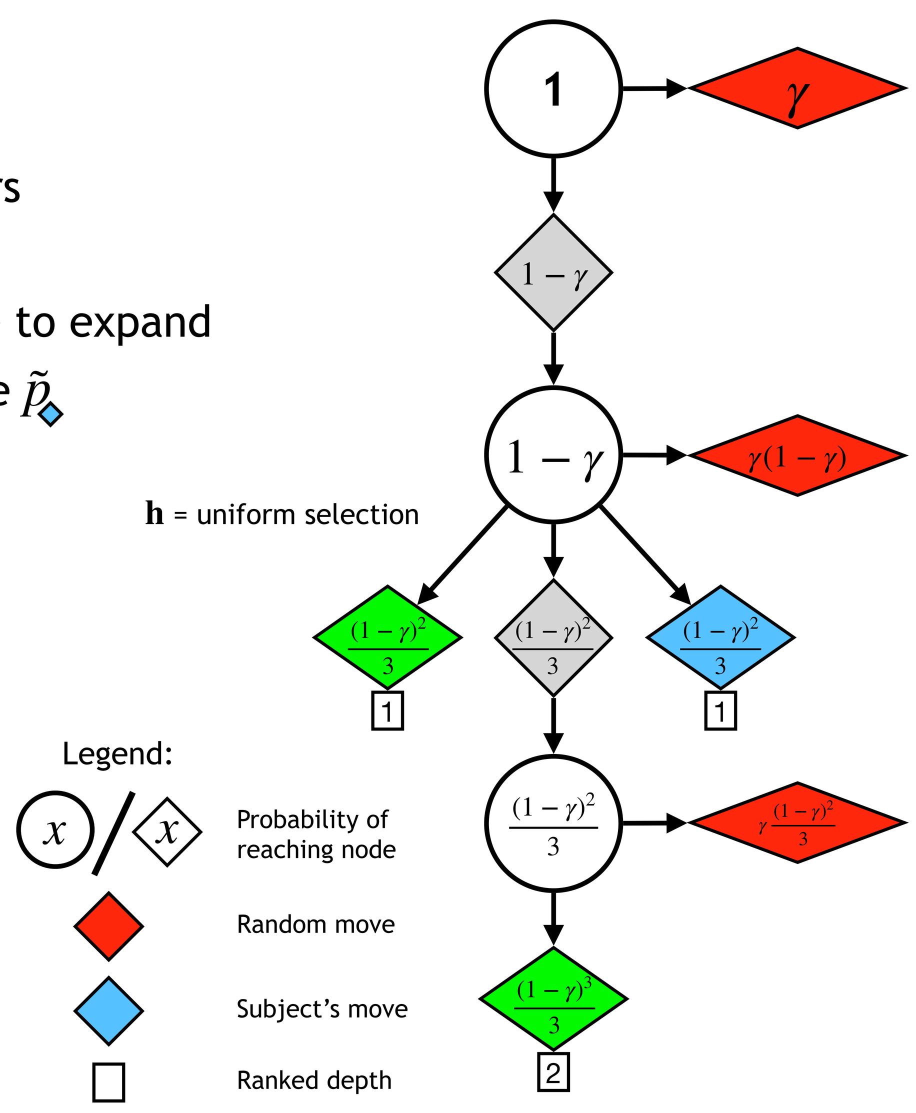
- Subgoals
- Represent cars that have to be unblocked
- All must be unblocked before parent move is possible
- One subgoal considered at a time, exponential branching otherwise

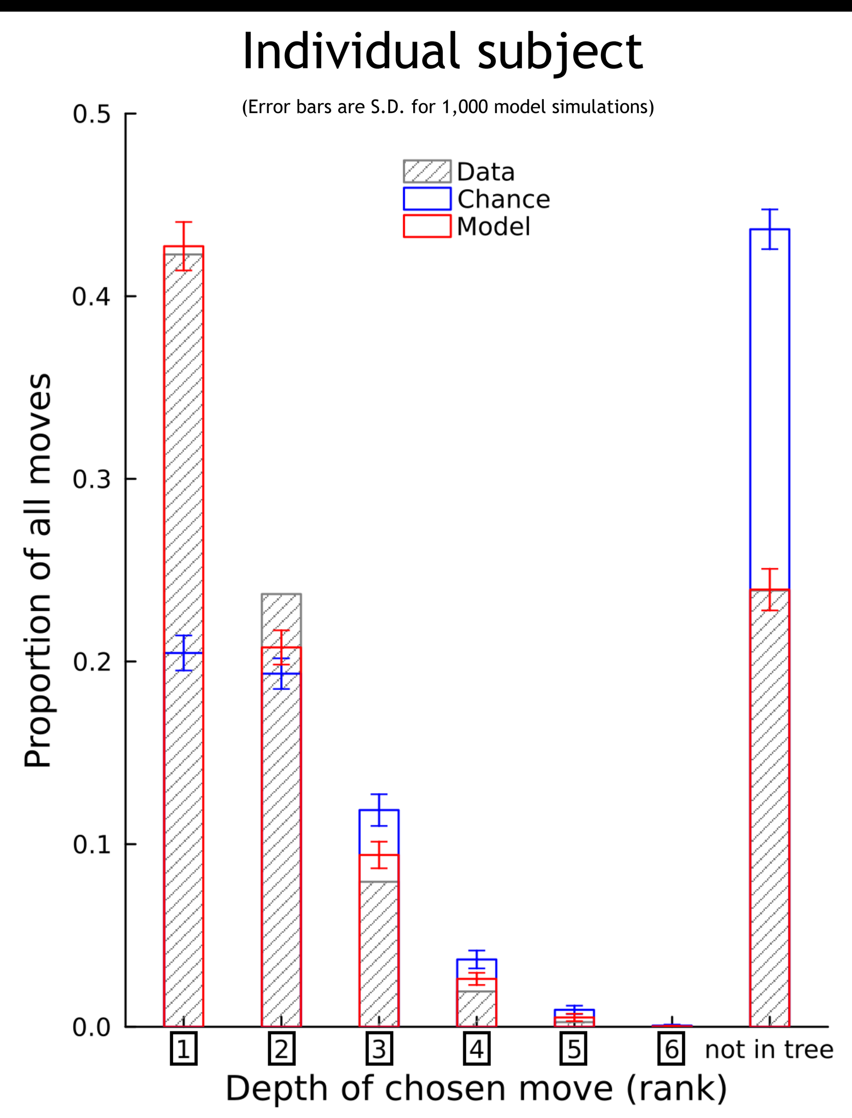
Results

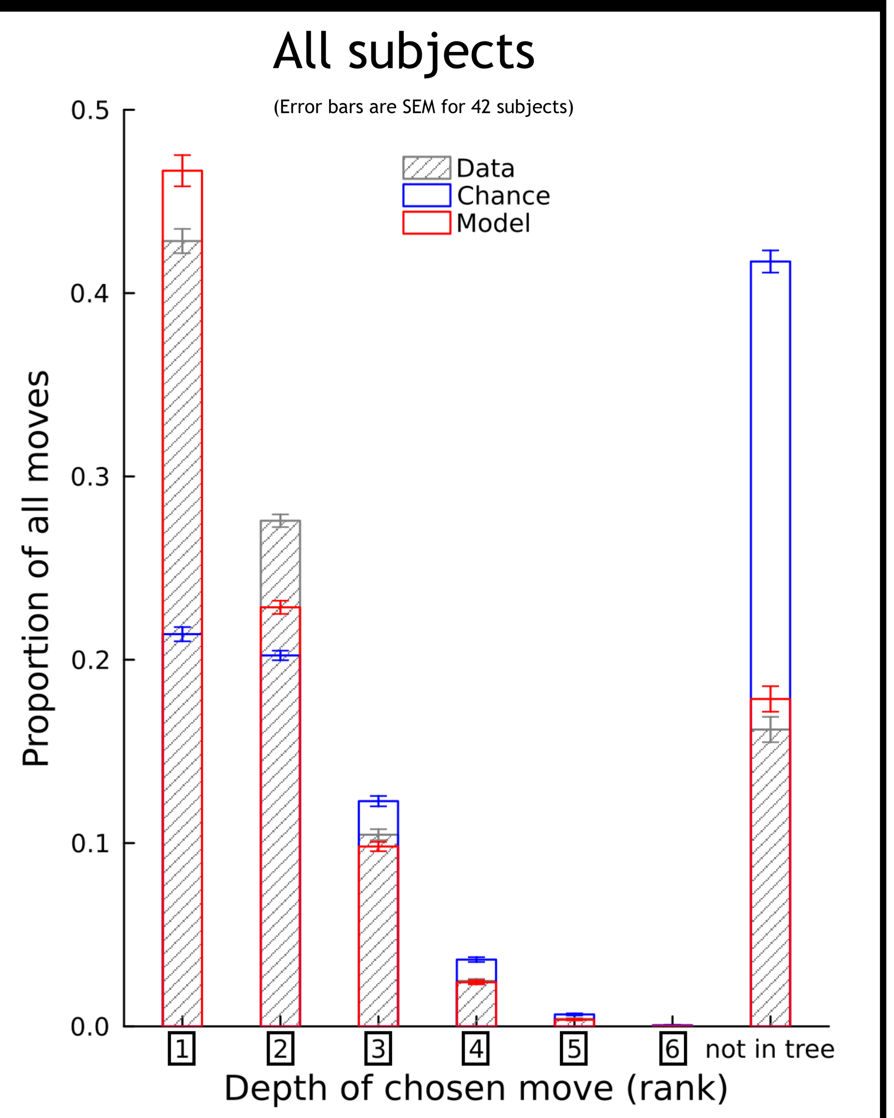
Model fitting

1. Get AND/OR tree
2. Propagate probability according to parameters
   - γ : stopping probability
   - $\mathbf{h}$: heuristics to decide which AND/OR node to expand
3. Find propagated probability of subject's move $\tilde{p}_{\diamond}$
4. Apply lapse rate to find $p_{\text{subject move}}$
5. Calculate log likelihood L
6. Repeat 1-5 for all moves and add together Ls
7. Maximize this sum of log-likelihoods
8. Repeat 1-7 for all subjects

$$L = \log(p_{\text{subject move}})$$
$$= \log\left(\frac{\lambda}{N} + (1-\lambda)\tilde{p}_{\diamond}\right)$$
$$= \log\left(\frac{\lambda}{N} + (1-\lambda)\frac{(1-\gamma)^2}{3}\right)$$







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