ADVENTURES OF HUMAN PLANNERS IN MAZE SEARCH TASK

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How do people plan ahead?

- **Prior work** in behavioural economics and psychology has focused on two-choice monetary gambles and bandits.
- **Goal**: Build models of planning in sequential spatial tasks (e.g. searching for an object).
- **Method**: Generalize three principles—utility maximization, utility discounting and probability distortion—that influence decision making to naturalistic context.

Models

Noisy Maximization

$$\sigma(\mathbf{Q})_k = \frac{\exp(-Q_k/\tau)}{\sum_j \exp(-Q_j/\tau)}$$

Probability Weighting

$$\pi(p) = exp(-|\ln(p)|^{\beta})$$

Expected Utility (EU)

$$Q_{EU}(N_i) = p_i(s_i + e_i) + (1 - p_i)\min_{c_j \in C(N_i)} Q_{EU}(c_j)$$

Discounted Expected Utility (DU)

$$Q_{DU}(N_i) = p_i(s_i + e_i) + \gamma(1 - p_i)\min_{c_j \in C(N_i)} Q_{DU}(c_j)$$

Probability Weighed Utility (PWU)

$$Q_{PWU}(N_i) = \pi(p_i)(s_i + e_i) + \pi(1 - p_i)\min_{C_j \in C(N_i)} Q_{PWU}(C_j)$$

Steps-Cells Heuristic (SCH)

$$Q_{SCH}(N_i) = k \cdot s_i - c_i$$

Steps Heuristic (SH)

$$Q_{SH}(N_i) = s_i$$

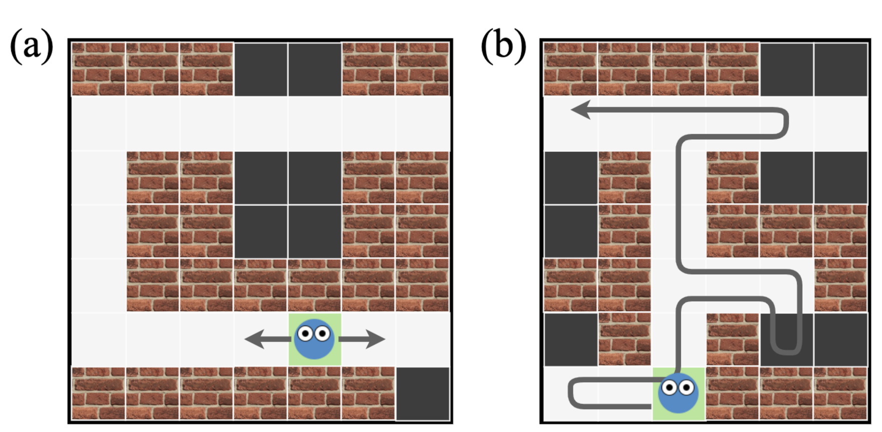
Cells Heuristic (CH)

$$Q_{CH}(N_i) = -c_i$$

Notations:

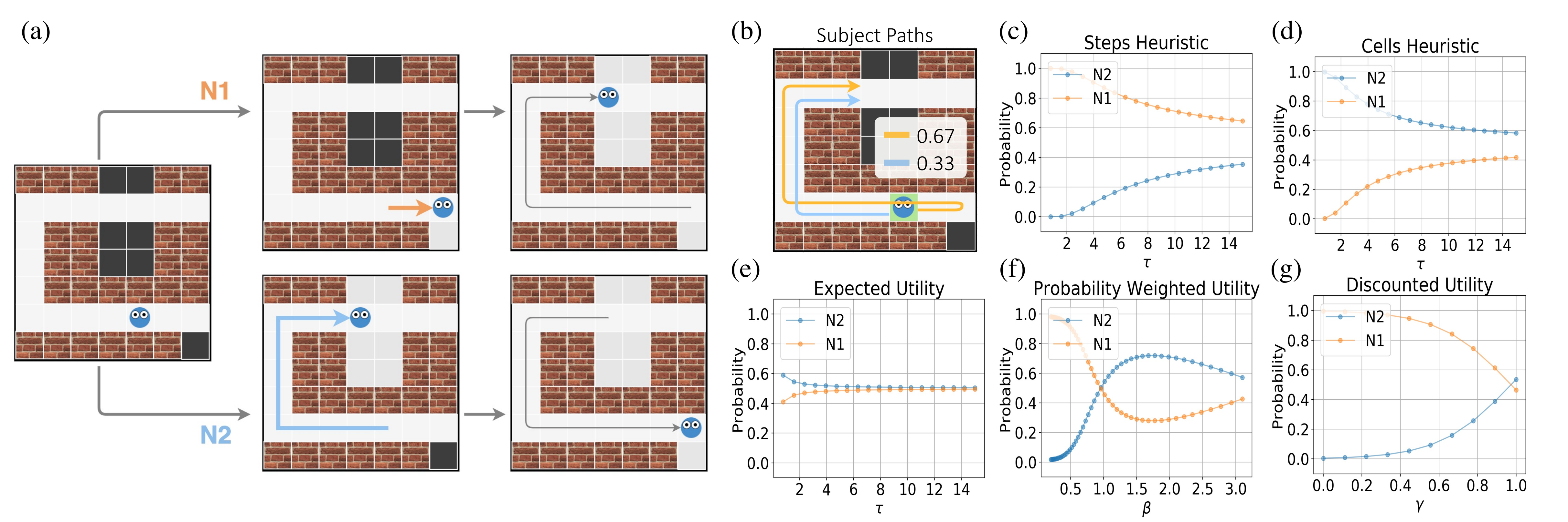
$C(N_i)$:= children nodes of N_i; p_i := probability that the exit is found at N_i; s_i := number of steps to reach N_i from the root node; e_i := expected number of steps to the exit from N_i if the exit is found at N_i.

Maze Search Task (MST)



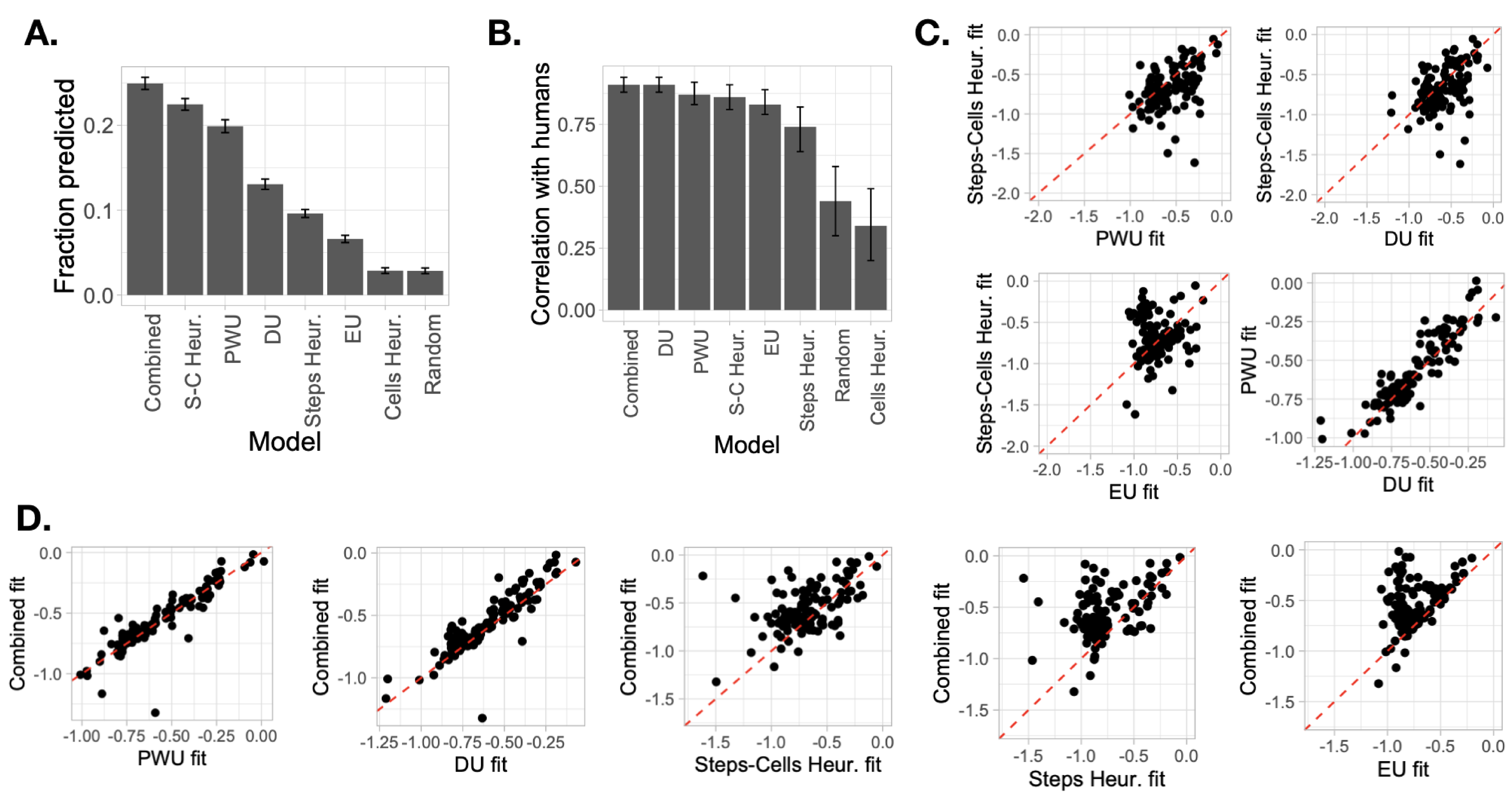
(a) An example of a MST. The avatar can move to any adjacent cell that is not a wall. The goal is to find the exit (red cell) in as few steps as possible. **(b)** Hypothetical search trajectory in a larger MST.

Decision Tree and Node Values



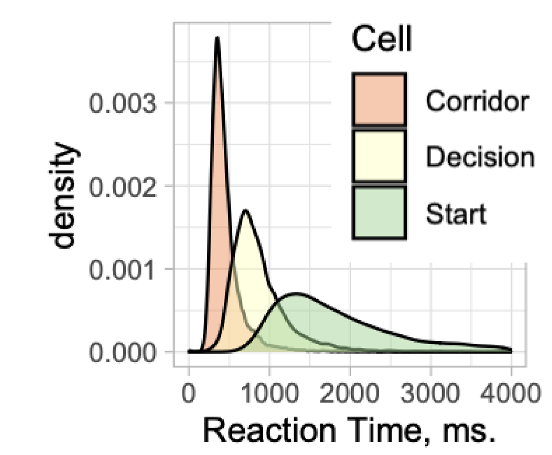
(a) MST translated into decision tree for analysis. **(b)** 67% of subjects visited the closer room first, while 33% of subjects visited the larger room first. **(c)**-**(g)** Values of nodes for different models.

Model-Based Analysis



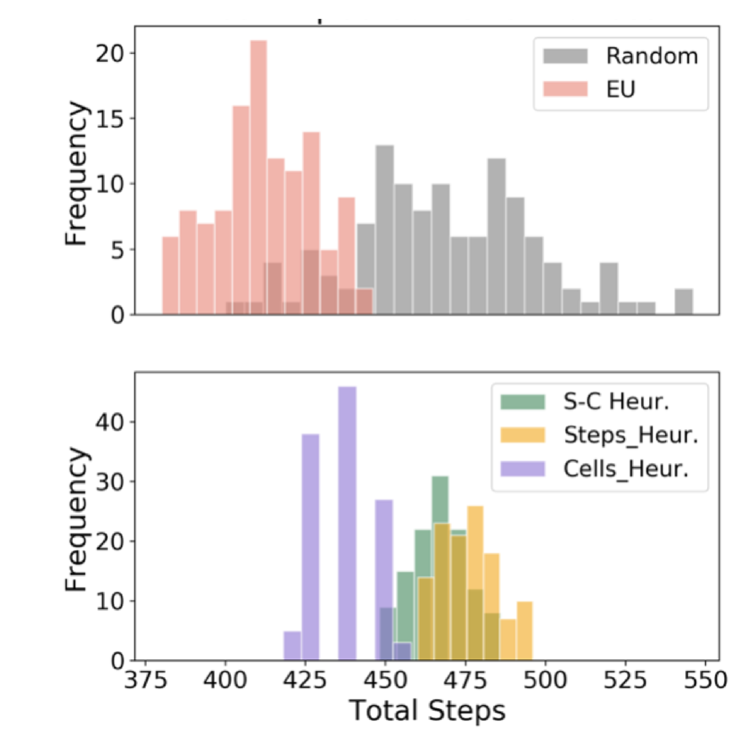
A. Model selection with four fold cross validation. Combined and SC Heuristic models are most popular. **B.** Correlation between aggregate subject data and node values by models. Most models explain aggregate subject data well. **C.** Pair-wise comparison between model fits to individuals according to 4-fold cross-validation. Each dot represents a person. **D.** Pair-wise comparison between the fits of the Combined model, and the fits of six other strategies.

Model-Free Result



People take a few seconds to study the map, move quickly through corridors, and pause whenever new information is observed.

Best expected performance



The expected performance of models measured as the total number of steps aggregated over all mazes, if following a greedy strategy under the given model.

Future Work

- Understand the relationship between **inferred computational strategies**, self-reports, and performance on cognitive benchmarks
- Investigate how human planning computations may emerge on the algorithmic level from using **sampling-based computations** with sparse samples, such as those based on MCTS [1]