The objective of this work is to test the hypothesis that the brain network statics and dynamics, namely the structural and functional connectomes, are consistent with a Resource Discovery Network (RDN). A RDN is a probabilistic network in which agents follow paths in the graph, searching for resources. Practically, a RDN can be viewed as the road network along with searching agents, e.g. taxi/Uber-drivers searching for customers. Each edge in the network has a traversal cost, and a probability of finding the resource on, or close to it. The objective of an agent is to find a resource at minimum (expected) cost. In the brain, the agents are communication signals, and a resource may be a subgraph of the connectome with a certain level/pattern of activity, or a similar object. If the brain is a RDN, it will contribute to the understanding of neural coding. Specifically, this will indicate that codes are formed by a process of search and discovery on the structural connectome (SC).

To test our hypothesis, we use the structural connectome to construct the network, and then take the probability of each edge from the FC. Then we evaluate the error of four increasingly accurate search algorithms, starting with a Random Walk and ending with the decision-theory [2] based Expected Cost Minimization algorithm introduced in [1]. The error of a search algorithm SA is computed as follows. For each pair of nodes v and w that are not necessarily neighbors, we compute \( f(v,w) \) which is the probability that a search using SA and starting from v, ends at w. Then the error of SA is the sum of \( |f(v,w) - FC(v,w)| \) over all pairs of nodes v and w. In other words, the FC serves as the ground truth. The hypothesis is verified if algorithm error decreases as its expected cost decreases.

**Resource Discovery Network**

![Diagram of Resource Discovery Network](image)

Each edge has a cost and a probability

Cost of traversing the edge \( e_{ij} \): \( c_{ij} \)

Probability of finding a resource on \( e_{ij} \): \( p_{ij} \)

**Taxi driver search for a customer modeled as Resource Discovery Network**

![Diagram of Taxi driver search](image)

Cost of traversing the edge \( e_{ij} \): \( c_{ij} \)

Time to traverse the edge \( e_{ij} \)

Probability of finding a resource on \( e_{ij} \): \( p_{ij} \)

**Could neural coding be explained by a RDN Search?**

Resources: neuronal configurations with some properties

Signals search for resources in the brain network

**Plan to test hypothesis that brain is a RDN**

Based on Structural Connectome (and part of Functional Connectome) generate an RDN

Check if increasingly sophisticated RDN search algorithms get closer to ground truth (remaining part of Functional connectome)

**Algorithms evaluated: Demonstration of move at a vertex**

Single step look-ahead:
- Random Walk
- Greedy
- Smart Greedy

Multistep look-ahead:
- Expected Cost Minimization
  - Find a path of minimum expected cost;
  - Move at an intersection depends on rest of network

**Proximity of algorithm SA to ground truth**

For each pair of nodes v and w: Compute \( f(v,w) = \) the probability that a search using SA starting from v ends at w.

\[
\text{Error}_{SA} = 2\sum_{v} |f(v,w) - FC(v,w)| \frac{n(n-1)}{n(n-1)}
\]

**Hypothesis verification**

- SA1: Random Walk
- SA2: Greedy
- SA3: Smart Greedy
- SA4: Expected Cost Minimization

Hypothesis is refuted if some \( Error_{SA1} - Error_{SA_{i+1}} \) is positive

**Experimental verification: in progress**

Data used is the 2514 node parcellation in [3].

**References**