Modeling Memories of Large-Scale Space Using a Bimodal Cognitive Architecture

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Overview

- Issues in representation and reasoning about Large-scale Space
  - Simplification
  - Errors & Distortions in Geographic Recall
- biSoar
  - Cognitive state in Soar vs biSoar
  - LTM in the bimodal case
- Models of Simplification & Geo Recall
- Golden Nuggets & Coal

Issues in representation and reasoning about Large-scale Space

- Spatial information represented in pieces, some metrical while others symbolic.
- Simplification
  - Recalled routes are simplified in various ways.
    - Curves are straightened, angles made closer to 90 or 180, regions and objects ignored etc.
- Errors & Distortions in Geographic Recall
  - San-Diego Reno Example.
    - Subjects asked about the spatial relation between San-Diego and Reno. Many incorrectly report that SD is to the West of Reno.
    - This distortion points to a hierarchical model of representation.

Space of Explanations

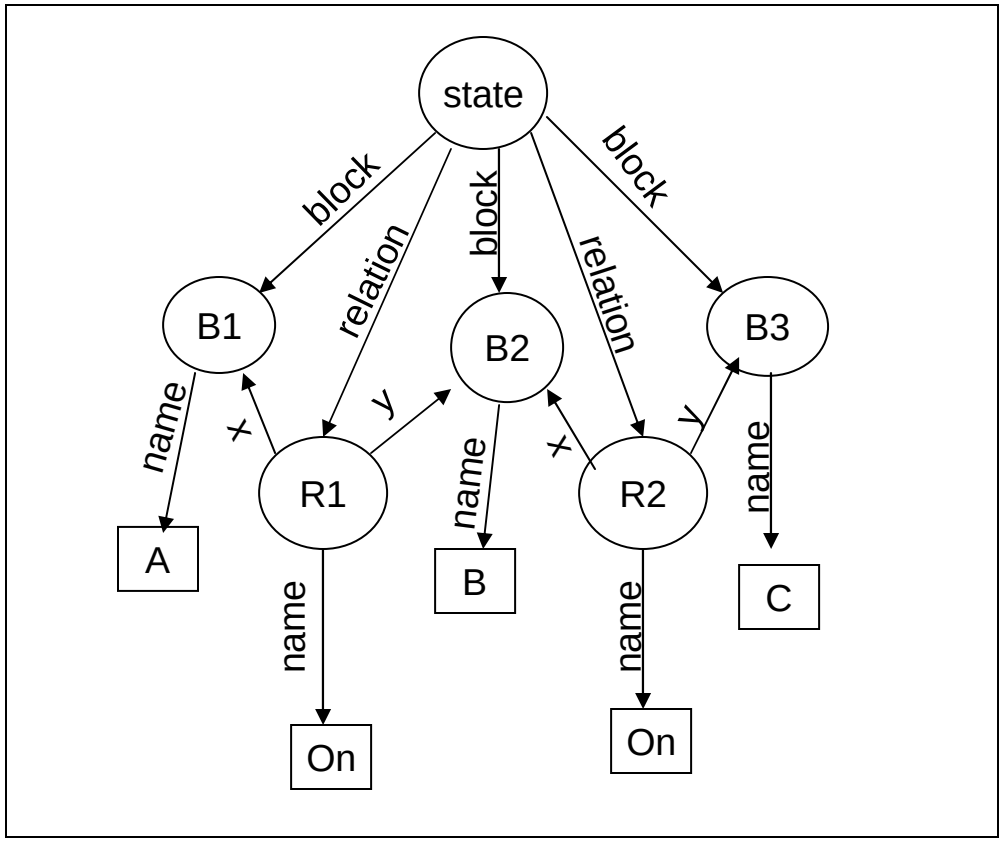
- Architectural - appeals to the specifics of the architecture.
- Content
  - Strategy
    - E.g.: algorithms
  - Knowledge
    - E.g.: particular pieces of information

Diagrammatic Representation System (DRS)

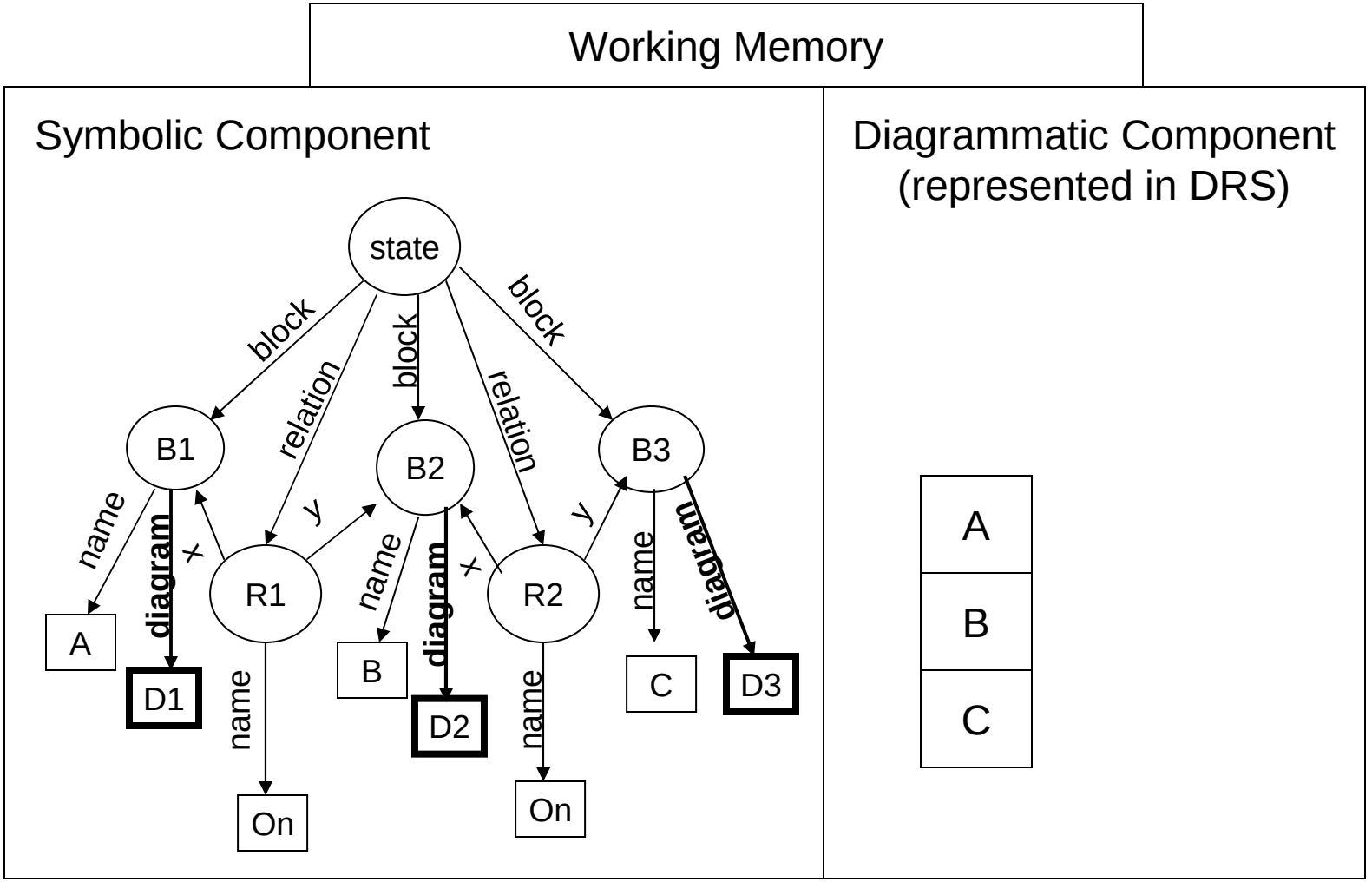
- Diagrams are represented as a configuration of diagrammatic objects, each with their complete spatiality.
- Three object types – *points, curves, regions*
- *Perceptual Routines* – processes that act on diagrams. Ex: Left-of, Inside-Of etc.
- *Action Routines*: create or modify diagrams subject to given constraints

Cognitive State in Soar

Working Memory

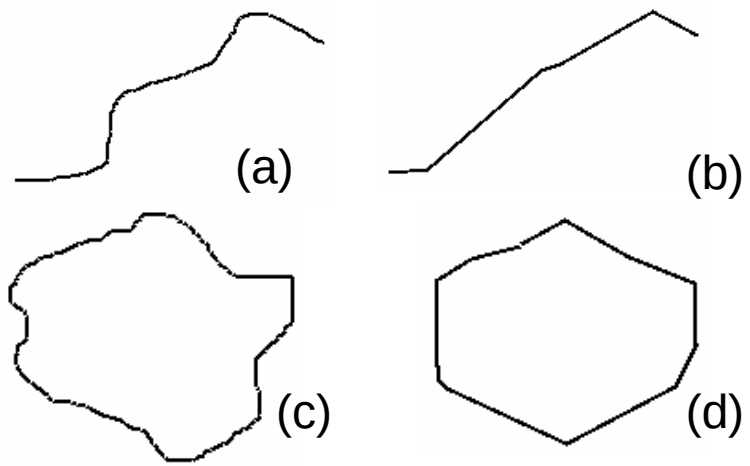


Cognitive State in biSoar



External Representation to WM

- Agent attends to only relevant parts or aspects of the diagrammatic objects in the external world.
- This results in a simplified version of the object in WM
- Implemented as an *Attend* method that is part of any perceptual routine that acts on the external world



(b) and (d) show the result of applying the Attend *operator to (a) and (c) respectively*

LTM in biSoar

- LTM is also bimodal: rules composed of both symbolic and diagrammatic components.
- Both the LHS and RHS can be bimodal.

Matching in biSoar

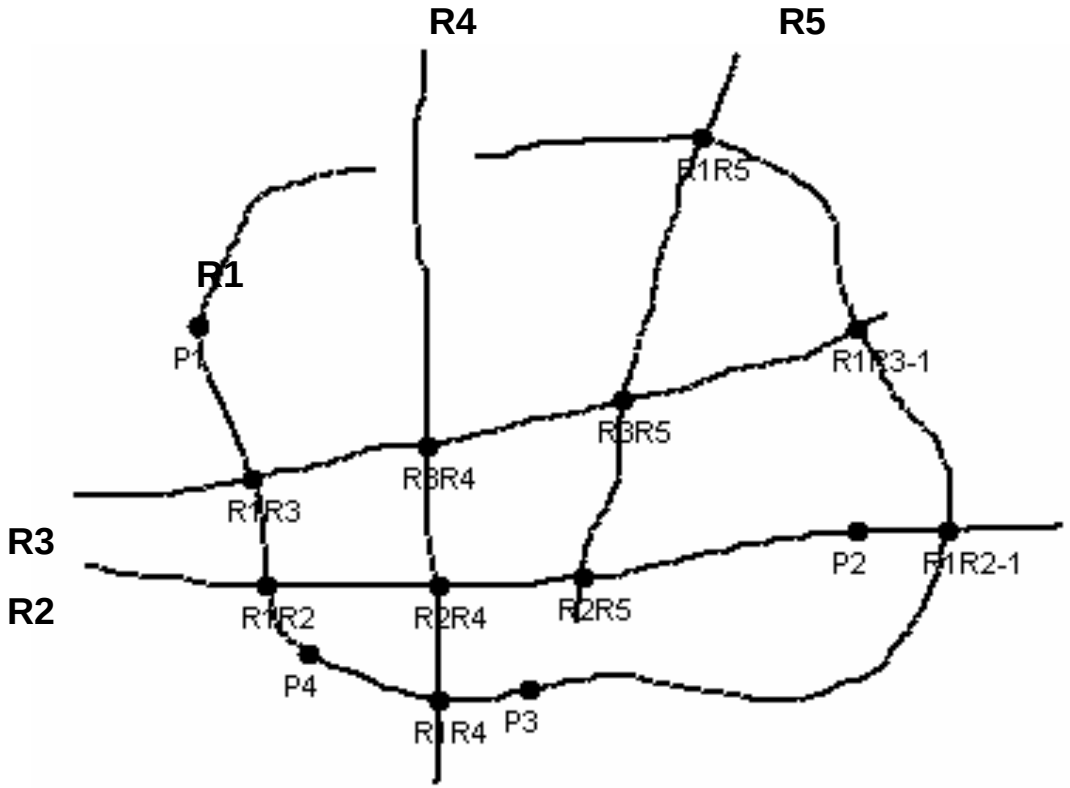
- No diagram-to-diagram matching – open issues.
- Working implementation: LTM rules only have symbolic components in the LHS, and they are matched against the symbolic components of WM.
- Both the symbolic and DRS components of WM are modified according to the RHS of the matching LTM rule.

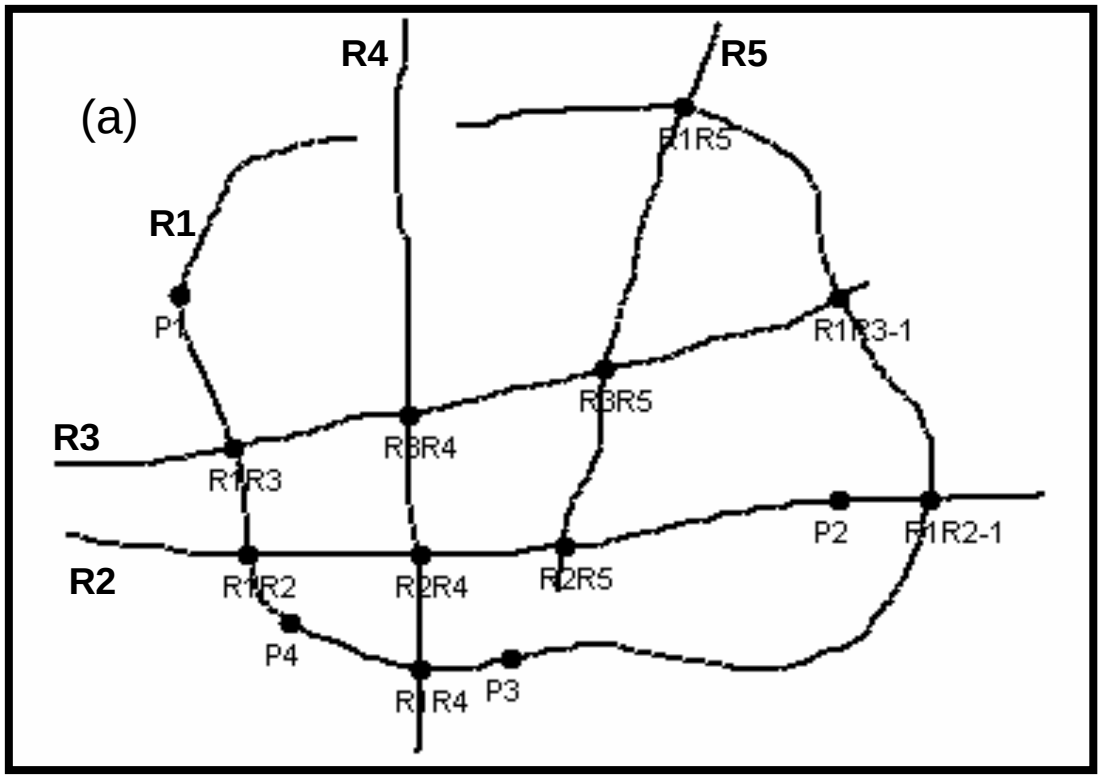
Chunking in biSoar

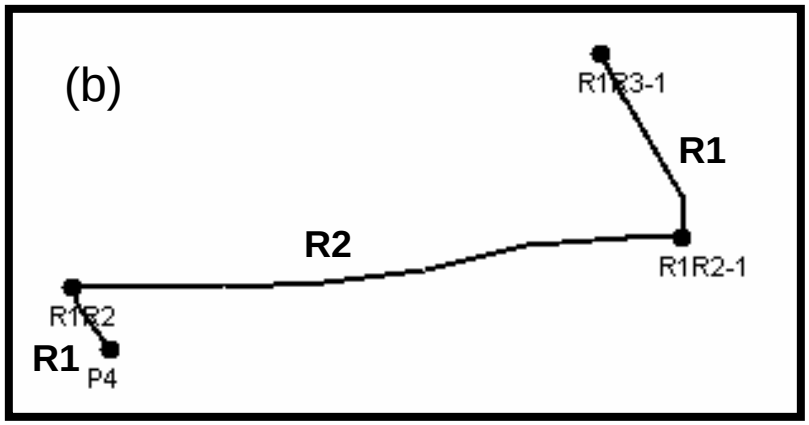
- Chunking proceeds as usual.
- We originally sought an explanation of simplification in the special properties of bi-modal chunking.
- But it became clear to us that there is no explicit simplification in chunking – whatever simplification was present in WM as a result of Attend is reflected in corresponding element in LTM.

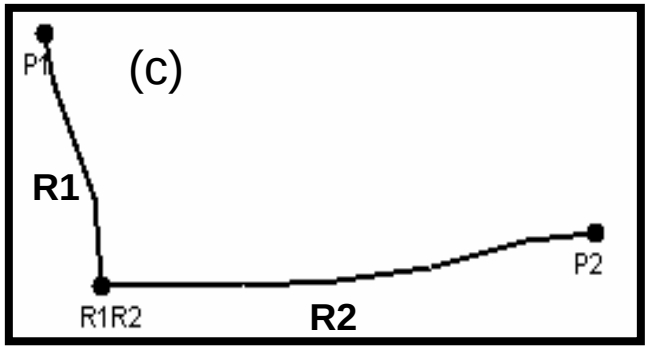
Simplification in Wayfinding

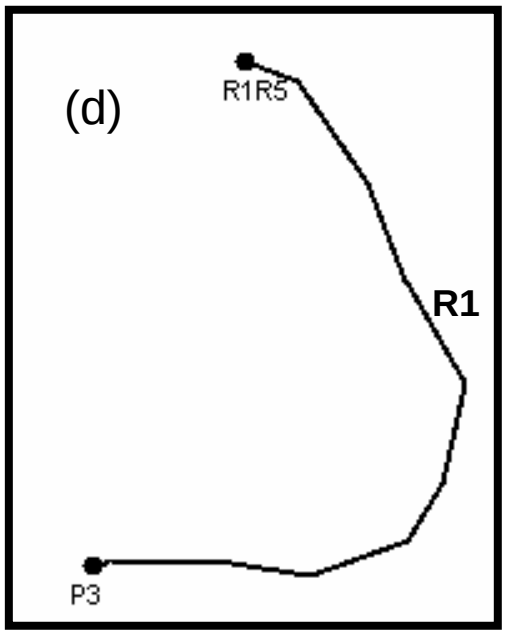
- The agent is given the task of finding various routes in the map shown below

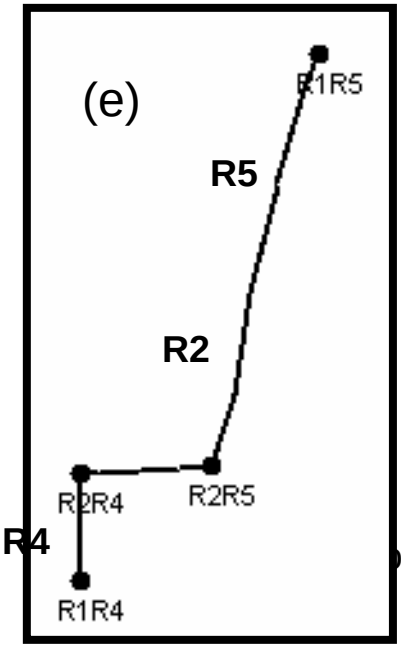












Routes recalled by the agent 1.

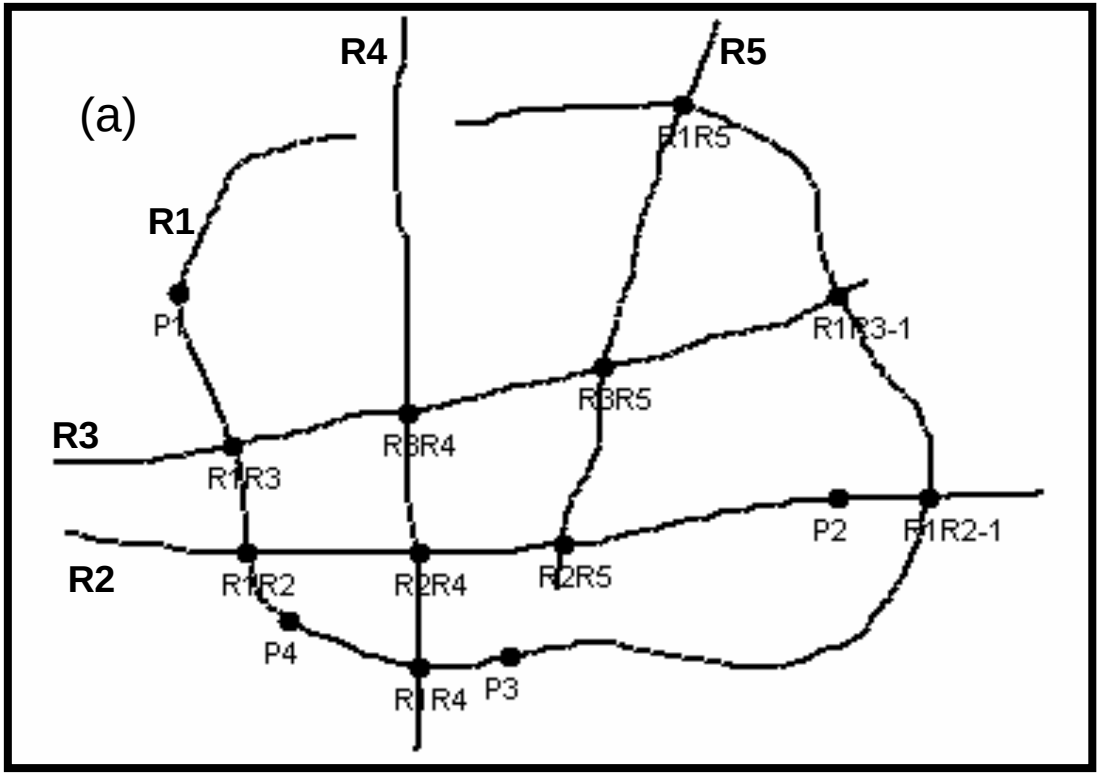
a) Map

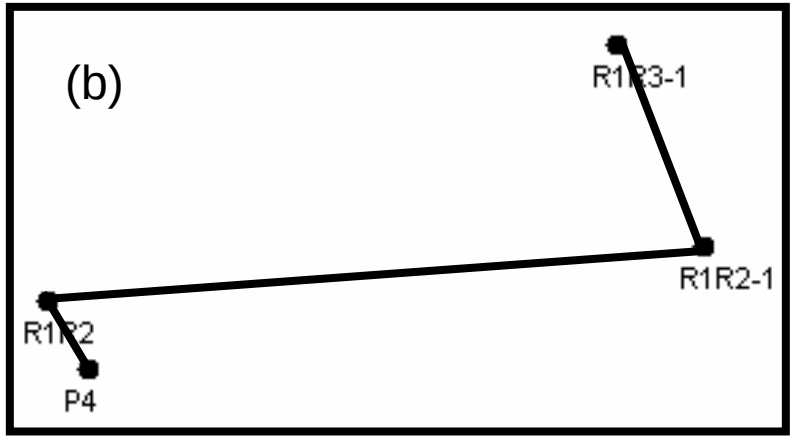
b) Route from P4 to R1R3-1

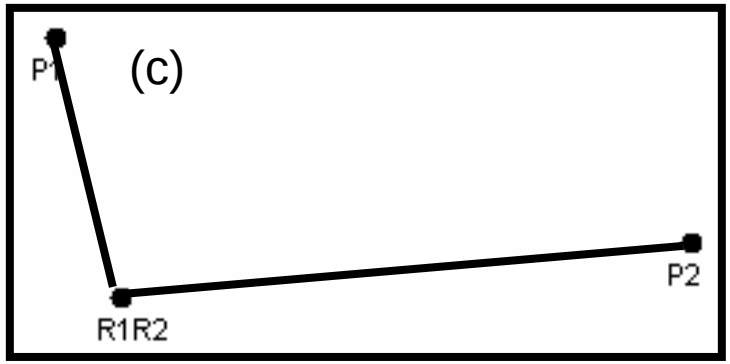
c) Route from P1 to P2

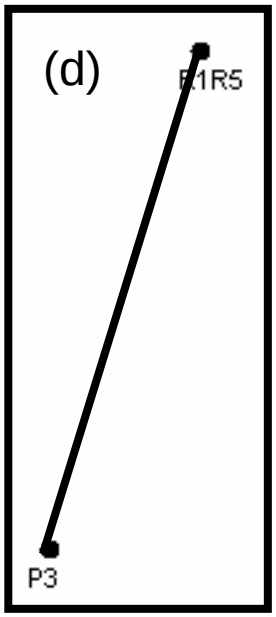
d) Route from P3 to R1R5

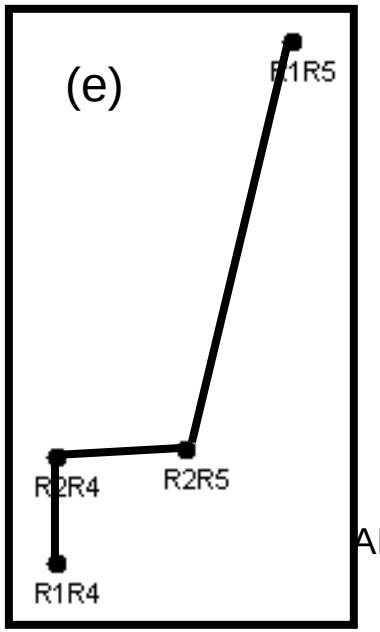
e) Route from R1R4 to R1R5











Routes recalled by the agent 2.

a) Map

b) Route from P4 to R1R3-1

c) Route from P1 to P2

d) Route from P3 to R1R5

e) Route from R1R4 to R1R5

San-Diego Reno Example in biSoar

- biSoar allows a modeler to model a variety of agents with differing pieces of knowledge
- 3 examples –
  - Agent 1 – agent has a diagram in LTM of California, Nevada, SD and Reno.
  - Agent 2 – agent has symbolic information that SD is south of SF and Reno is east of SF. This is used to create a visualization from which the relationship between SD and Reno is extracted.
  - Agent 3 – agent has symbolic information that SD is in California, Reno is in Nevada and California is to the West of Nevada. This is used to create a visualization from which the relationship between SD & Reno is extracted.

Agent 1

- Agent has a diagram (Fig 6) in LTM in which California, Nevada, SD and Reno are marked. The relationship between SD and Reno is simply extracted from the diagram. Note that even in this case, the agent can make a mistake if the diagram is incorrect .

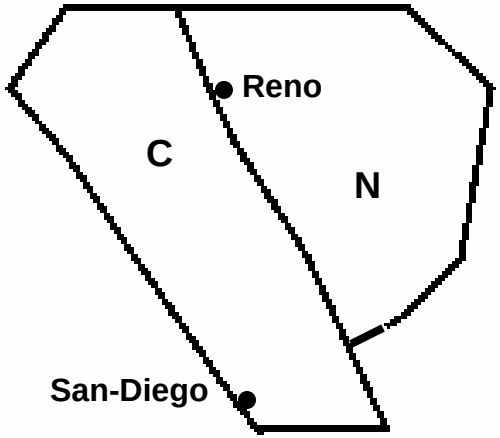


Diagram in LTM of the agent for model 1

Agent 2

- Agent has symbolic information that San-Diego is to the south of San-Francisco and that Reno is to the east of San-Francisco. Uses this information to construct a diagram and extract the relation between SD and Reno.

Diagram constructed by the agent implementing Model 2

Agent 3

- Agent has symbolic information that SD is in California, Reno is in Nevada and that California is to the West of Nevada. Uses this information to construct a diagram from which the relation between SD and Reno is extracted.

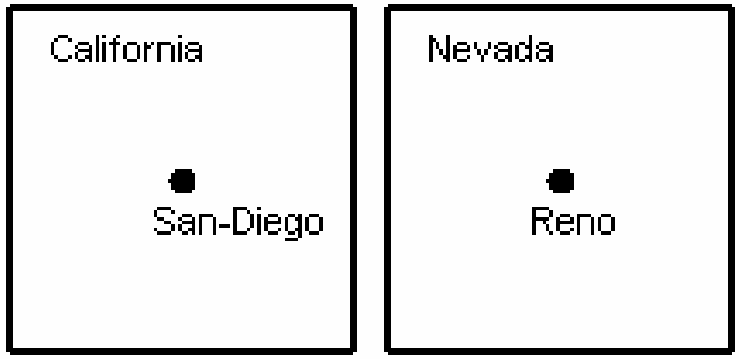


Diagram constructed by the agent implementing model 3

Future Work

- Diagram composition from diagrammatic pieces.
  - Scale and size variance
  - Overlapping parts
- Spatial Learning
  - Chunking and knowledge transfer between related but different tasks
- Explaining various other spatial distortions and phenomena
- Diagram matching

Golden Nuggets

- Bimodal cognitive state allows the representation of spatial information in chunks with symbolic and metrical content.
- Bimodal Attend and chunking can provide an (architectural) account of simplification phenomenon.
- biSoar is flexible/versatile enough to be able to model agents with different knowledge/strategies as shown by the Geo Recall examples.
- Space of Explanations

Coal

- Crude approximation of attention
- Spatial distortions that are proving hard to model
  - Asymmetries in distance estimation
- Map learning is only a secondary source of spatial information.
- More general: Holes in account of Matching.