Implementing Cognitive Semantics in a Cognitive Modeling System

Deryle Lonsdale

Department of Linguistics & English Language
Brigham Young University
lonz@byu.edu

Cognitive modeling

- Purpose: model human behavior
  - agent-based: representation of world, self
  - goal-directed: decompose actions, subgoaling
  - learning: skills, behaviors, expertise
  - fatigue, emotion, attention, overload, confusion
- Plausibility: processes, time course, constraints
- Knowledge, memory, buffers, decay, activation
- Embodiment: perception, control, agency, grounding, interaction (e.g. robotics)

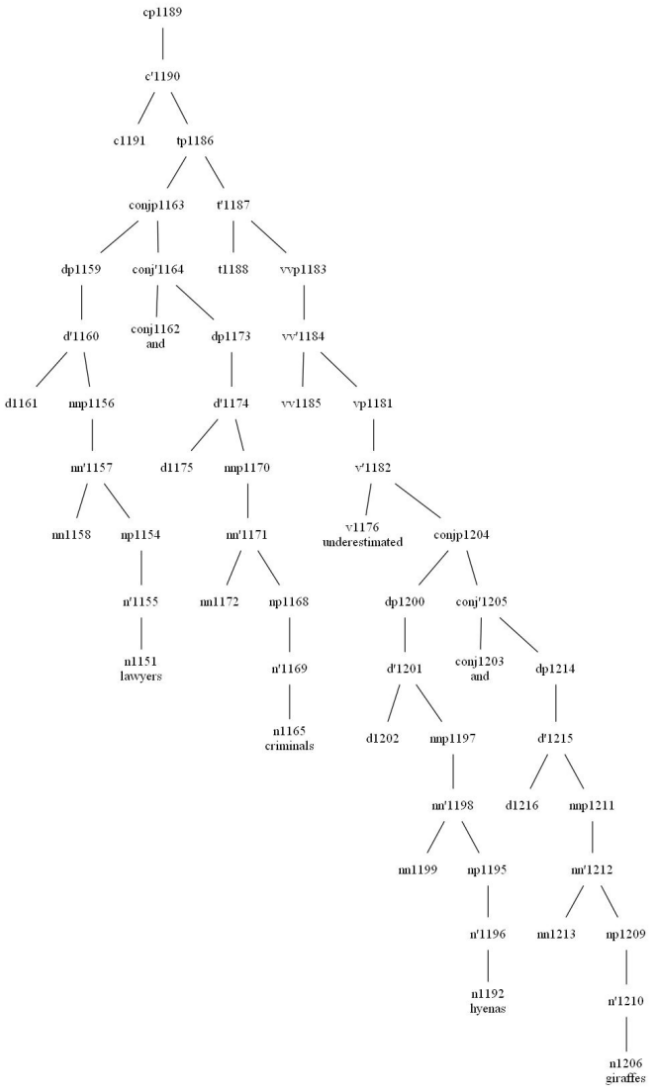
Modeling language use in Soar

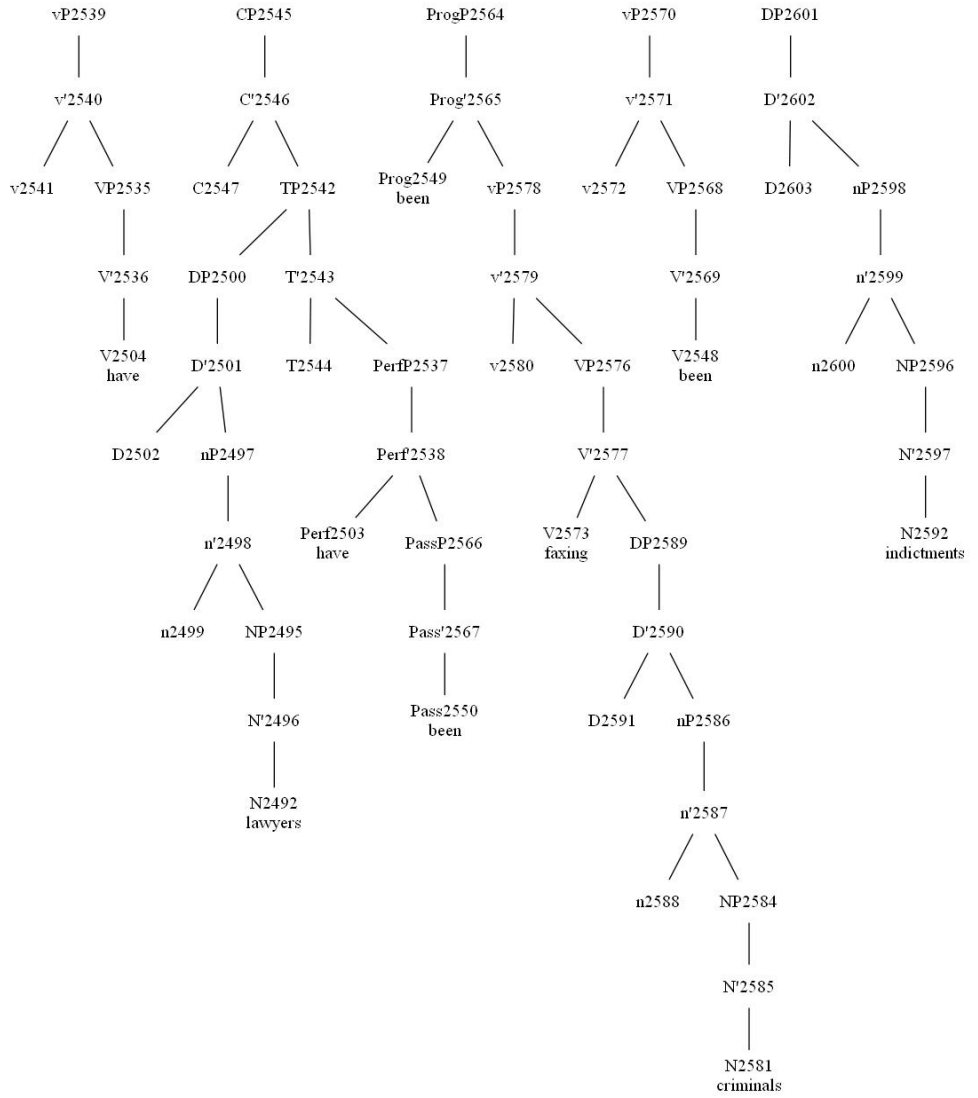
- Lexical access (WordNet, etc.)
- Parsing: syntax, strategies, breakdown
- Semantic interpretation
- Incrementality
- Ambiguity resolution
- Generation, translation
- Discourse/dialogue, turn-taking, conversation
- Interleaving of subtasks
- Language/task integrations
- Acquisition, attrition, multilinguality

Syntax and semantics in Soar

- Syntactic representation has evolved
  - Principles & Parameters (Gov't & Binding)
  - Minimalist Program
- Semantic representation has evolved
  - Annotated models
  - Lexical-Conceptual Structure (loosely)
- Processing is incremental, interleavable
- Visualization via GraphViz
- Other formalisms are possible
  - This talk: Cognitive Semantics prototype

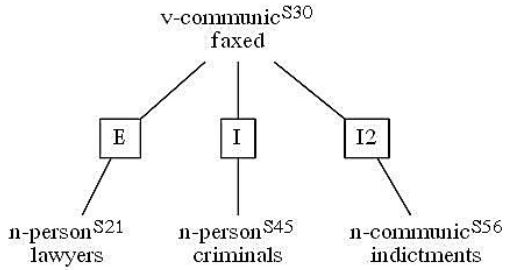
Sample parses

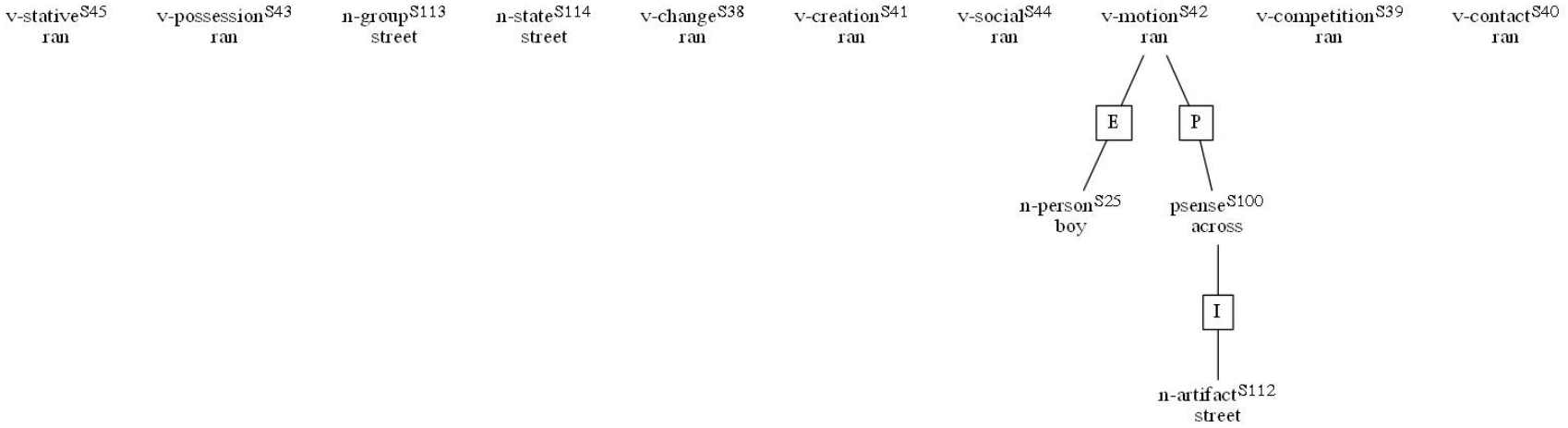




Sample semantic representations

- Undirected graph
  - Concepts
  - Labeled relations
- Annotated nodes
- All possible word senses





Holmqvist's proposal (1993)

- Cognitive Semantics
  - Inspired by—but not exactly—Langacker's Cognitive Semantics (1987)
  - Main difference: focus is temporal profile, processing, incrementality
- Cast in 1990's AI terms (theoretical only)
- In the meantime...
  - Proposal not yet addressed
  - Rise of cognitive architectures
- Time to re-visit!

Overview of semantic processing

1) Input evokes conceptual images
2) Lexicon, grammar inform superimposition of image schemes
3) Compositional image schemes enable semantic interpretation

Evoking concepts

- Language input is incremental stream of morphemes (phonology is excluded)
- Morphemes evoke concepts
- Concepts are represented as image schemata
  - things
  - processes
  - stative atemporal relations
  - complex atemporal relations

Image schema

- Abstract generalization over images; experiential
- Three main properties:
  - Wholes, Domains, Parts
  - Base, Matrix, Meronymy
- Other properties:
  - prototypicality
  - vagueness
  - dimensionality
  - directionality
  - boundedness
  - plexity
  - scale, proportion, paths, etc.

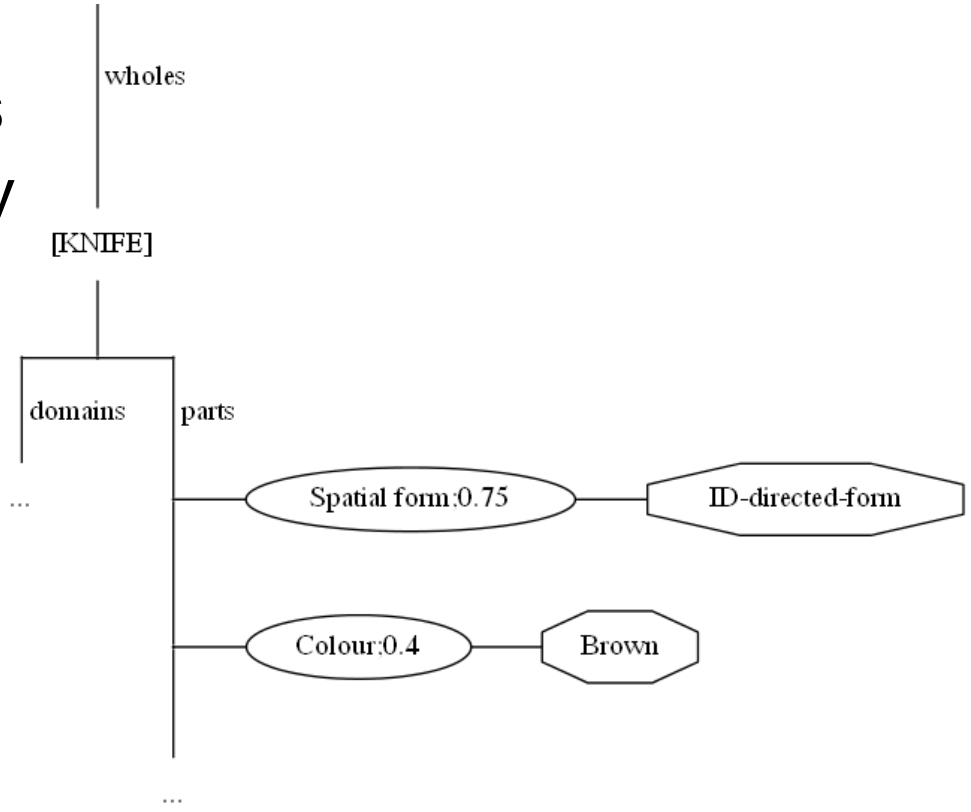
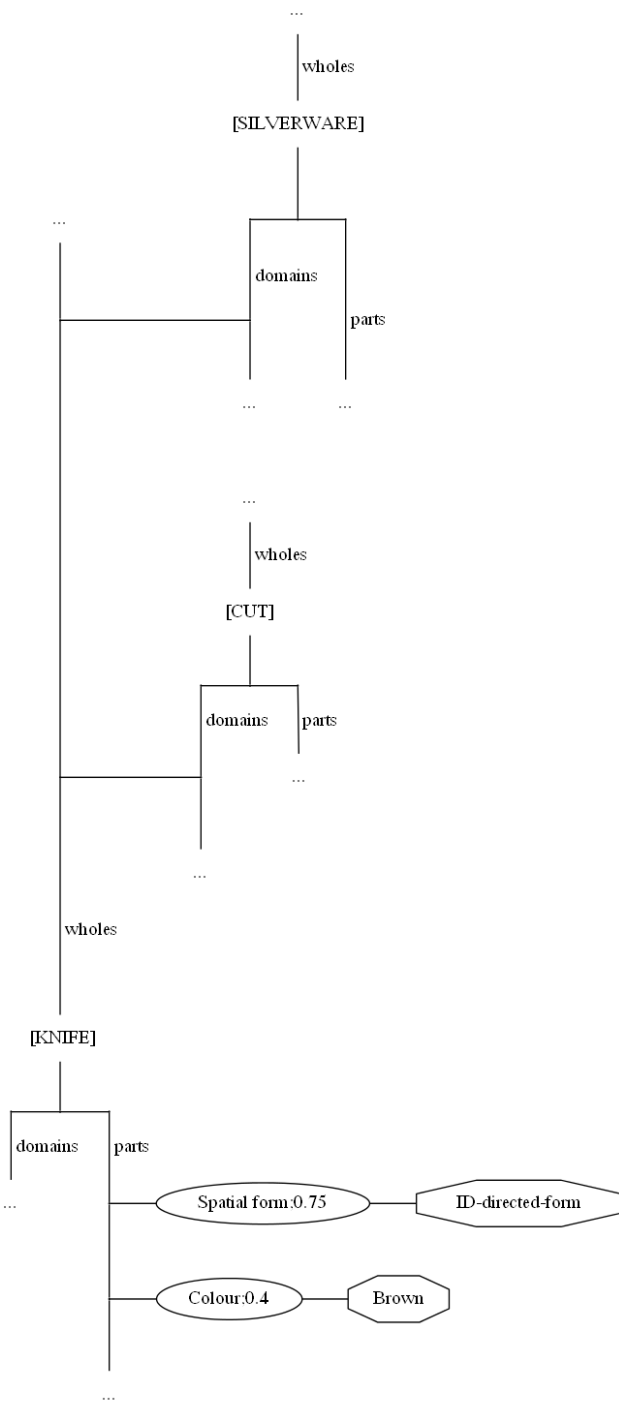


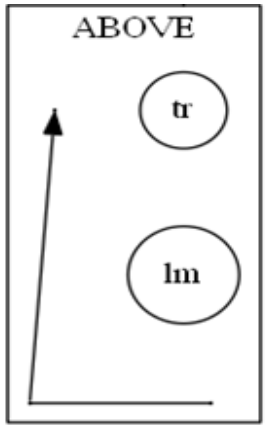
Image schemata

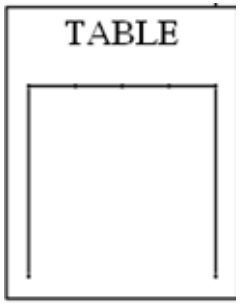
- Site: open role
  - Salience/prominence
- Superimposition: link
  - Lexicon
  - Processing
- Relation: mediates possible connections
  - Valence
  - Accommodation
- Can represent in GraphViz

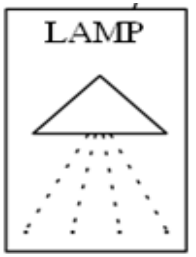


Basic concept structures

- Triggered primarily via valence relations
- “Lexical” inventory
- Viewpoint adjustments: turning, scaling, tilting, accommodation

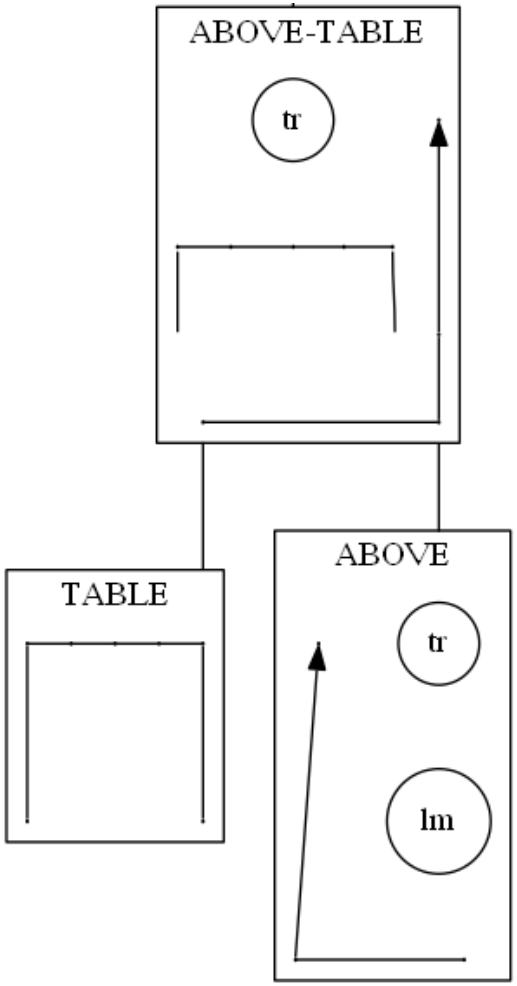




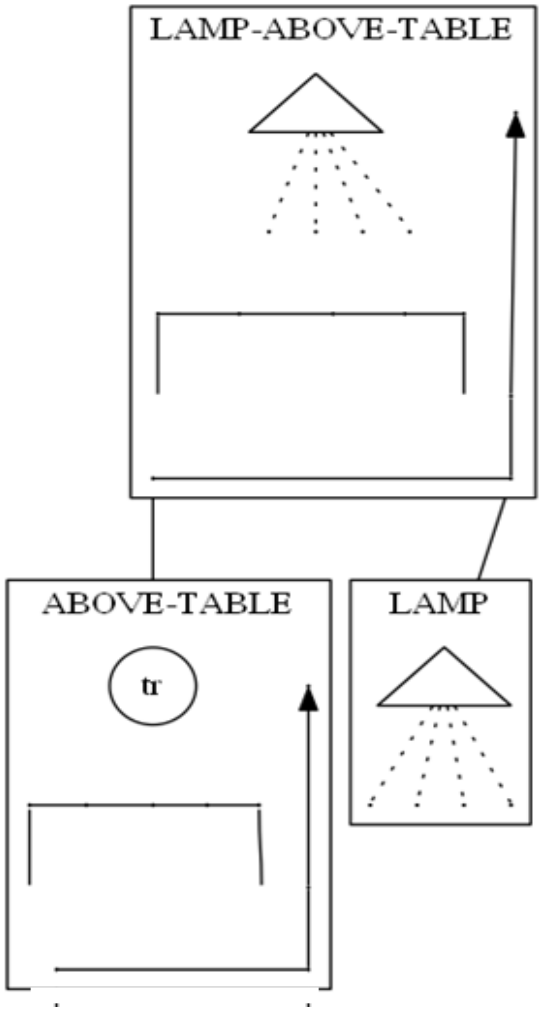


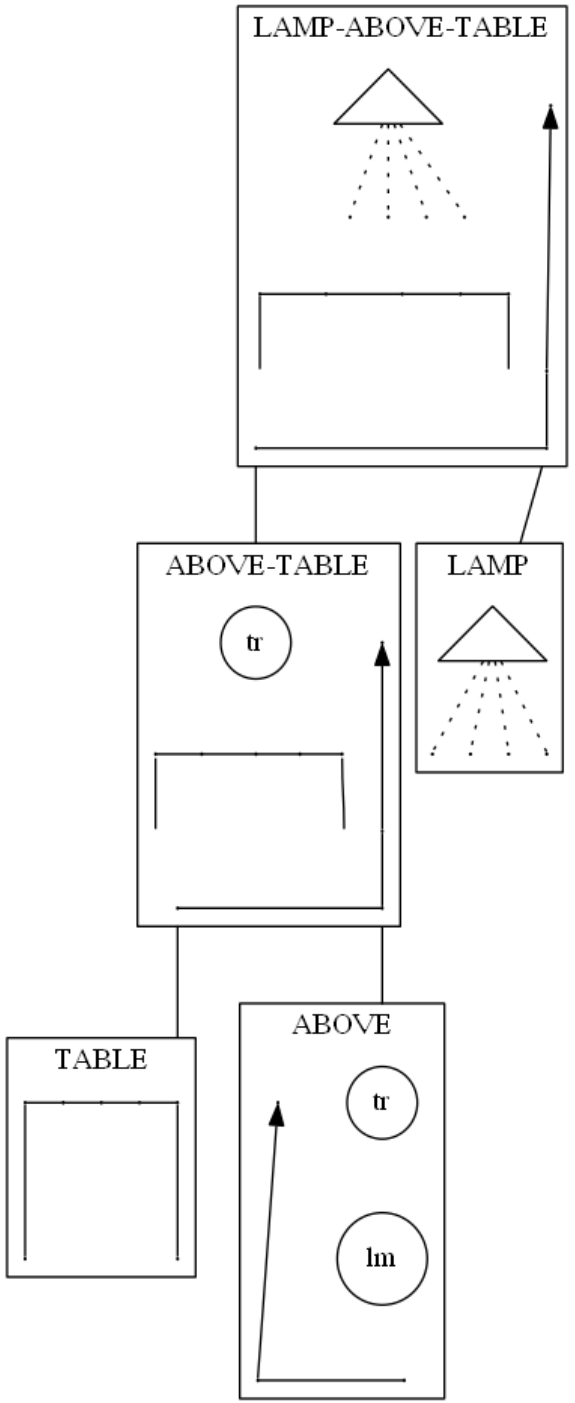
Superimposition

- Compositional
  - To the extent language is
  - Predication
  - Lex/syn/sem expectations
- Instantiation of placeholder parts
  - Trajector
  - Landmark
- Via accommodation
- Similar to unification



Processing traces





Accommodation

- Mechanism for suggesting, ranking, selecting possible attachments

- Inputs:
  - Sites (semantic expectation)
  - Lexical entries (grammatical expectation)
- Matches against Domains, Parts, Wholes
- Also considers possible schema variants

Accommodating valence relations

- APP (accommodation process population)
  - List of possible participants
  - Used to guide computation of possible links
- Several subprocesses
  - Disambiguation
  - Contextual linkage
  - Anomaly detection (metaphor, metonymy, prevarication, hedges)
  - Semantic garden paths

Points of correspondence

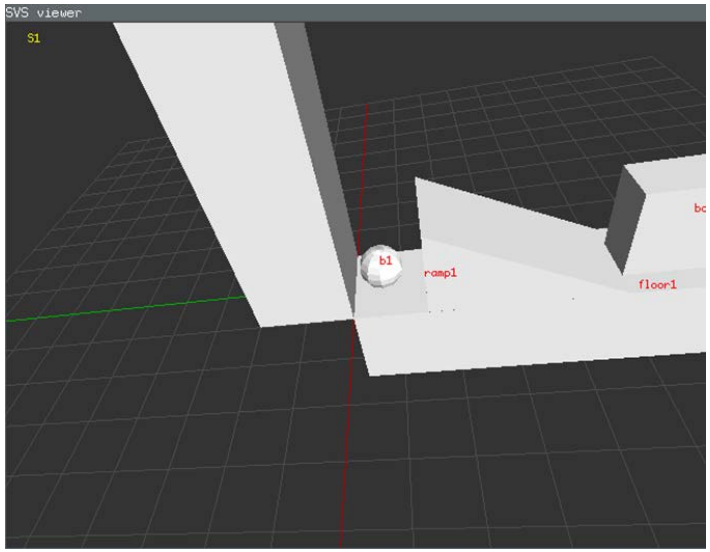
- Accommodation computation
  - Propose, evaluate, select, apply
  - Maps onto Soar operator decision cycle
- APP list
  - Similar to our sem assigners/receivers list
- Prune away inappropriate attachments in light of more context
  - Sem snips

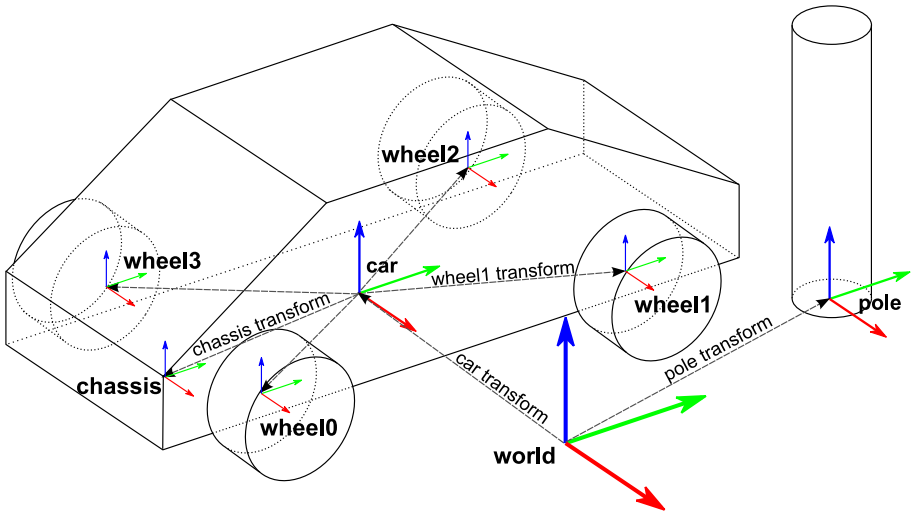
Observations so far

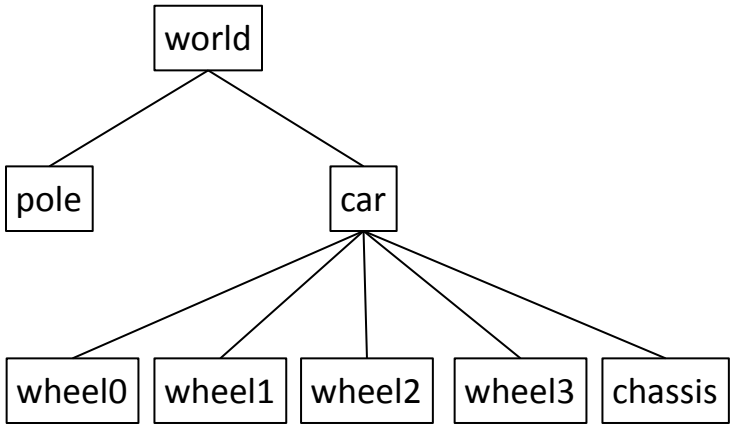
- Prototype implementation possible
  - Incremental
  - Compositional
  - Simple combinatory graphing with GraphViz
  - Done standalone or in concert with LCS
  - Machine learning isn’t discussed, but doable
- Challenges
  - Lexical graph primitives: time-consuming
  - Proposal coverage: sketchy vs. specific

Beyond simple box plots (Xu, 2013)

- Soar has a 3D scene graph environment
- Hierarchical organization of objects
- Node grouping, geometrical primitives
- Node positioning supports rotation, transforms, etc.
- Sends data into working memory, can be pipelined, can connect with 3D viewer
- Potential for natural language cognition







Future work

- Scale up language coverage
- Use Soar's native Spatial Visual System
- Metaphor detection/interpretation
- Generation from semantic representation
- Semantic garden paths
- Grounding
- Inferences

Thank you!

lonz@byu.edu