

COGNITIVE MODELING FOR FORMAL SEMANTICS

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1. INTRODUCTION

1. We outline the structure of a cognitively realistic semantic parser that incrementally constructs semantic representations (DRSs)
2. The parser composes and integrates semantic interpretations on-line
3. The parser evaluates new semantic representations relative to a model (database of known facts) stored in memory
4. The parser can model RT data and can predict the 'fan effect'

- https://people.ucsc.edu/~abrsvn/demo_hippie_in_town_1.mp4
- https://people.ucsc.edu/~abrsvn/demo_hippie_in_town_2.mp4

2. FAN EFFECT (ANDERSON, 1974)

Participants studied facts about person-location pairs. 10 examples:

- | | | |
|----------------------------|------------------------------|-----------------------------|
| a. A lawyer is in a cave. | b. A debutante is in a bank. | c. A doctor is in a bank. |
| d. A doctor is in a shop. | e. A captain is in a church. | f. A captain is in a park. |
| g. A fireman is in a park. | h. A hippie is in a park. | i. A hippie is in a church. |
| j. A hippie is in a town. | | |

- Each person concept – used 1, 2 or 3 times (=fan of 1, 2 or 3)
- Each location concept – used 1, 2 or 3 times (=fan of 1, 2 or 3)

In the test phase, participants had to accept targets (learned facts) and reject foils (novel facts)

Target		location fan			Foil		location fan				
RTs		1	2	3	RTs		1	2	3		
person	fan	1	1.11	1.17	1.15	person	fan	1	1.20	1.25	1.26
		2	1.17	1.20	1.23			2	1.22	1.36	1.47
		3	1.22	1.22	1.36			3	1.26	1.29	1.47

- (i.) the effect of 1-fan (intercept) is about 1.2s
- (ii.) latency is a non-additive function of fan: (1, 3)/(3, 1) faster than (2, 2)
- (iii.) the fan effects are approximately equal for targets and foils

3. BASIC ACCOUNT

DRS consists of three sub-DRSs:

1. $\left[\begin{array}{l} \text{DREF} : 1 \\ \text{PRED} : \textit{hippie} \\ \text{ARG1} : 1 \end{array} \right]$
2. $\left[\begin{array}{l} \text{DREF} : 2 \\ \text{PRED} : \textit{town} \\ \text{ARG1} : 2 \end{array} \right]$
3. $\left[\begin{array}{l} \text{PRED} : \textit{in} \\ \text{ARG1} : 1 \\ \text{ARG2} : 2 \end{array} \right]$

After constructing the DRS, the parser checks whether a matching fact is present in the model (learned facts in declarative memory).

Recall of fact i from declarative memory: parallel search driven by activation A_i . A_i modulated by spreading activation from sub-DRSs j . (Free params are in red below.)

$$A_i \approx \sum_j W_j S_{ji} \quad (1)$$

$$S_{ji} = S - \log(\text{fan}_j) \quad (2)$$

$$T = I + F e^{-A_i} = I + F' \prod_j \text{fan}_j^{W_j} \quad (3)$$

($F' = F e^{-\sum W_j S}$)

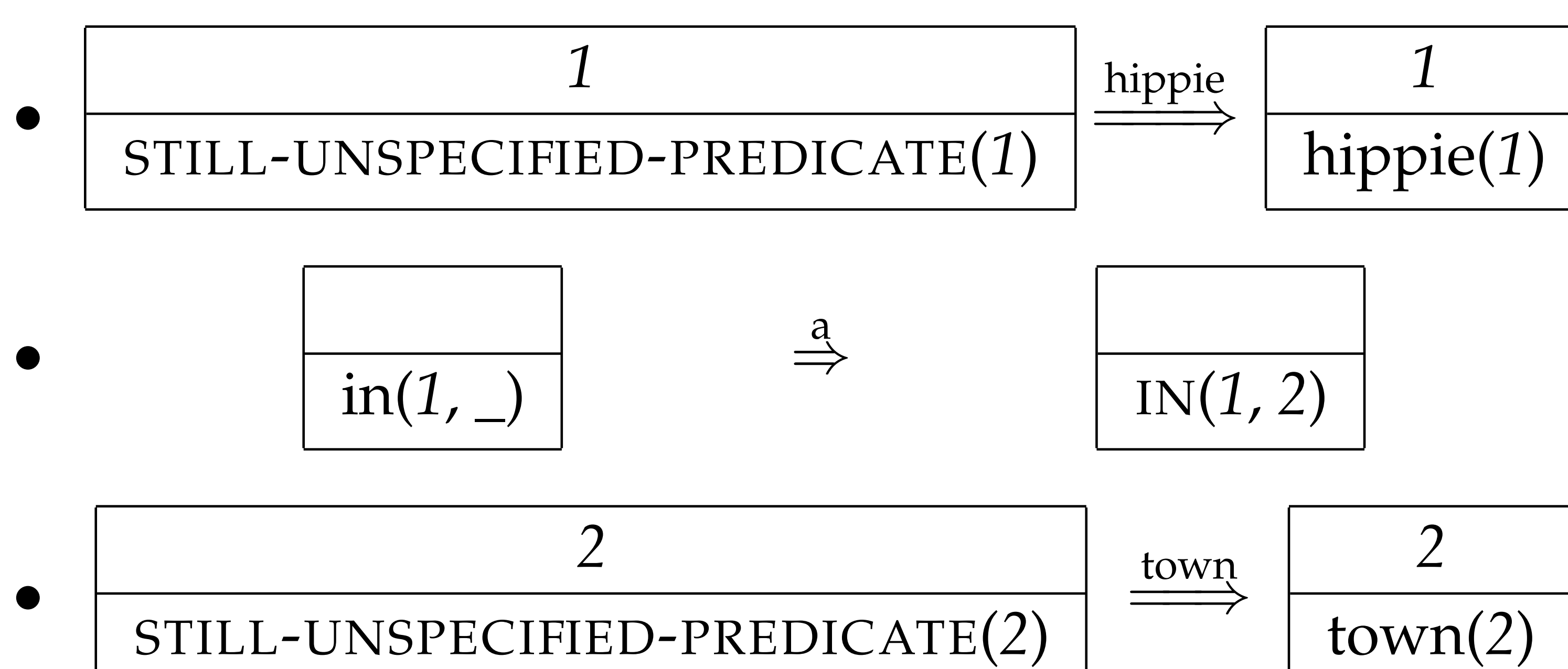
- (i.) by I in (3)
- (ii.) by $\prod_j \text{fan}_j^{W_j}$ in (3)
- (iii.) by parallel search

4. INCREMENTAL DRS CONSTRUCTION AND SEMANTIC EVALUATION

DRS construction as a set of production rules in ACT-R

Production rules: conditionalized actions

Left-corner parser interspersed with DRS construction; syntax and semantics built side by side



Evaluation as a recall from declarative memory. Fan effect due to sub-DRSs built during incremental interpretation.

Parameter estimates obtained by embedding the parser in a Bayesian model.

