Generating Communications Systems Through Shared Context

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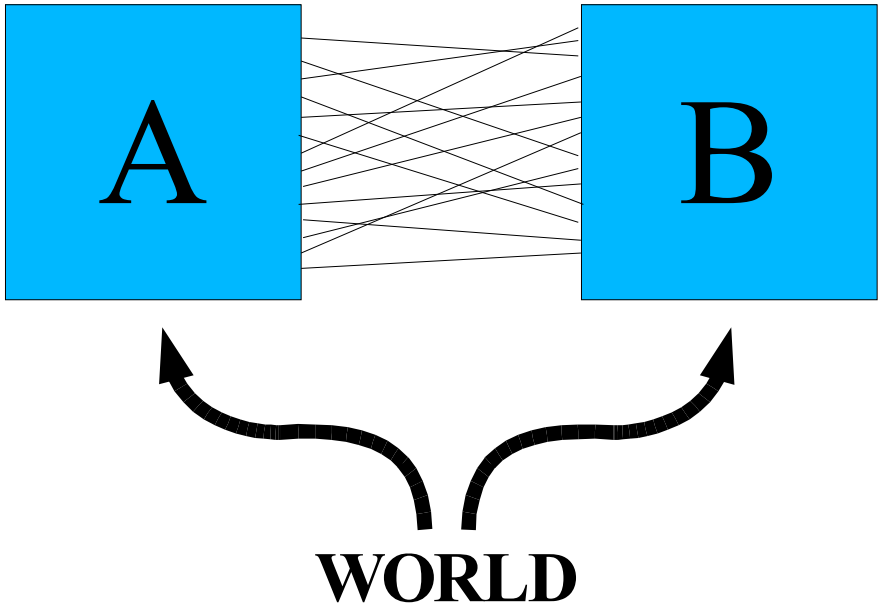
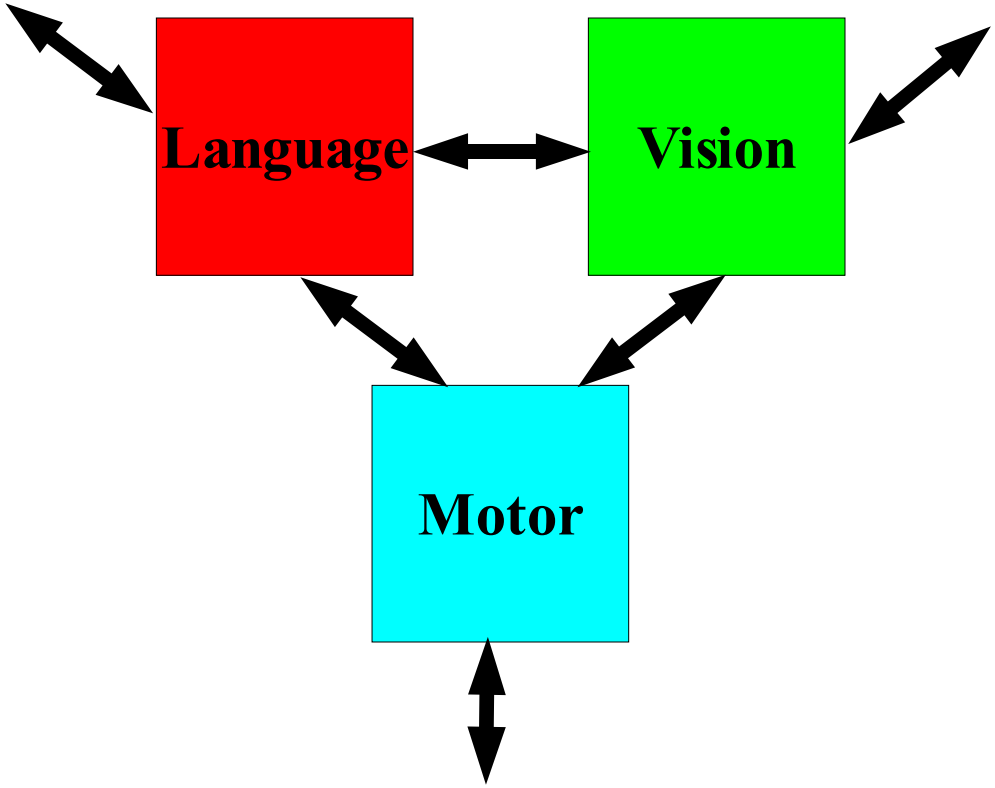


In a distributed reasoning system ...



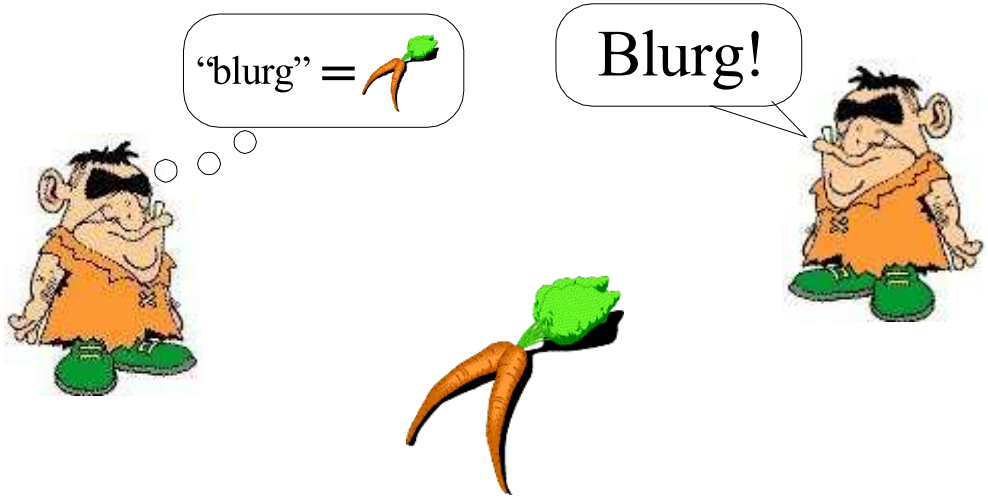
... how can components communicate symbols?

Vision

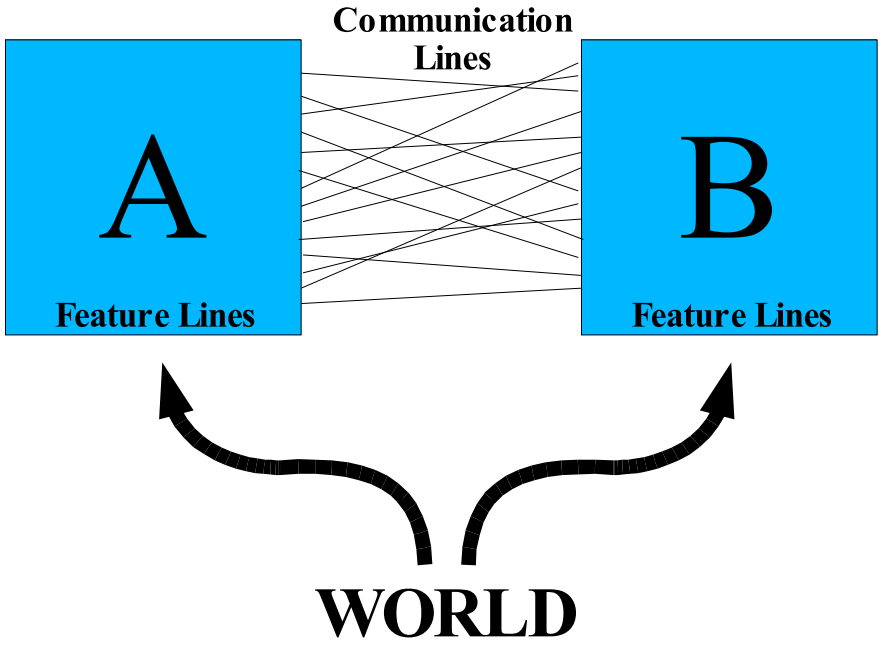
Bootstrap communication system from shared experiences of the external world

Inspired by Kirby's syntax evolution,

Yip & Sussman's constraint learning

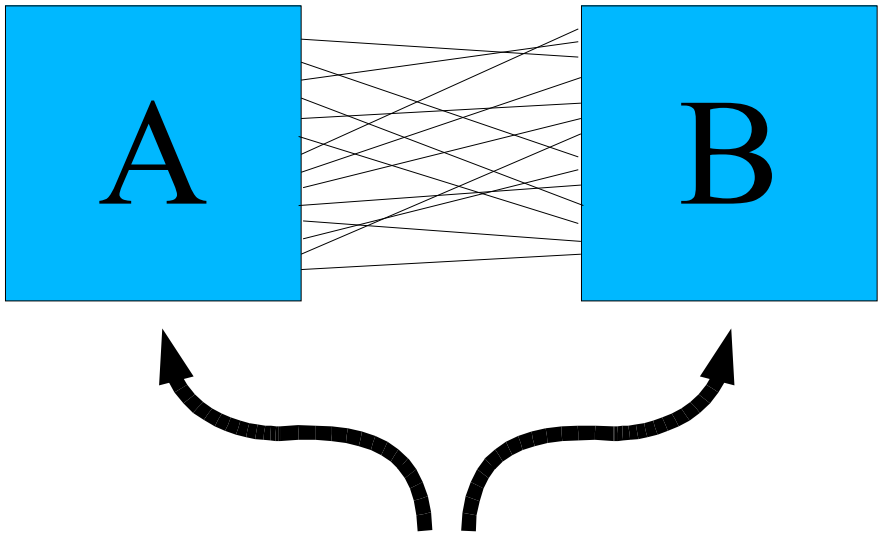


Problem Definition



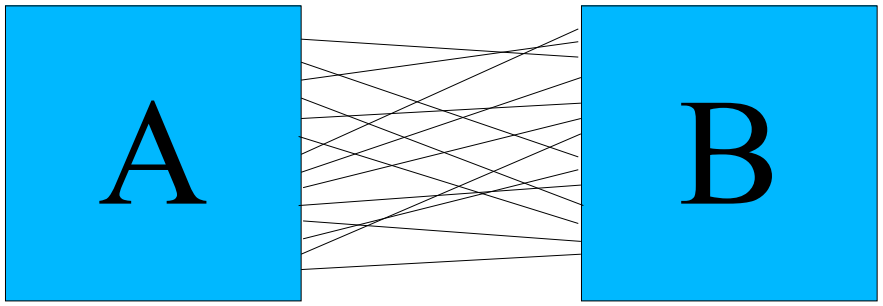
- World features: {(symbol, role), (symbol, role)...}
- Comm line values: 0, +1, -1, X

Training



{(bob, object), (mary, subject), (kiss, action)}

Testing



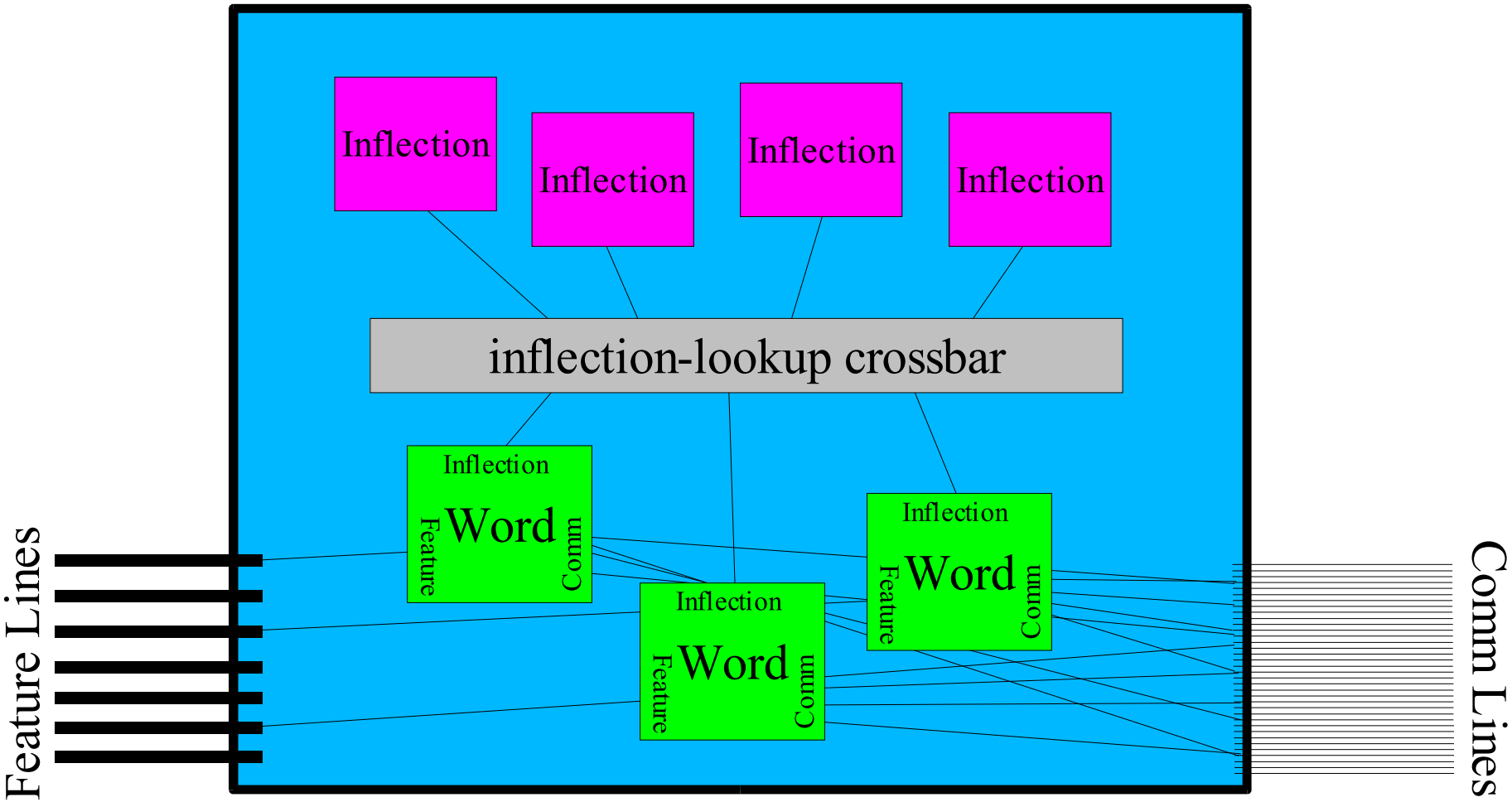
{(mary, subject),
(hammer, object),
(use, action)}

{(mary, subject),
(hammer,place),
(use,action)}

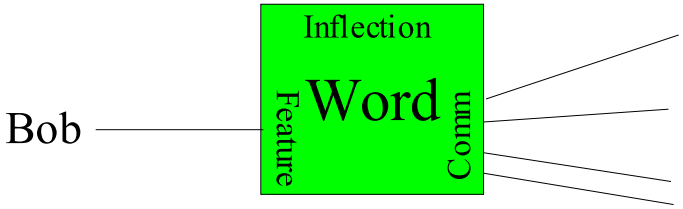
Design Space

- Fragile, flaky components
- Parallel replicated structure is cheap; complex designs are expensive
- Serial computation is slow
- Bidirectional use of learned data
- No time-domain signals

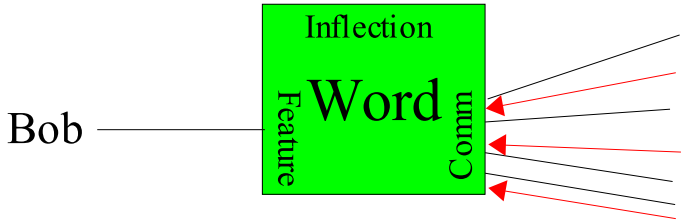
Bootstrapping Agent



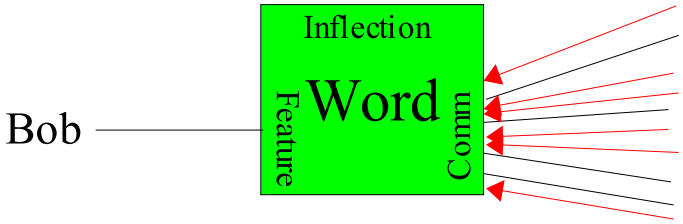
Learning a Word



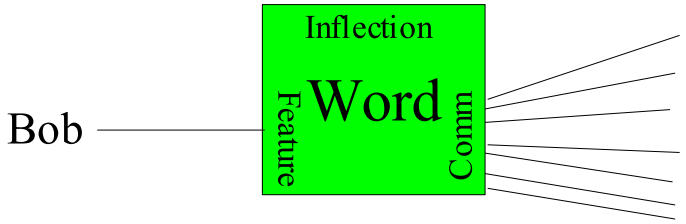
1. Choose random comm lines



3. Winnow possibles by intersection

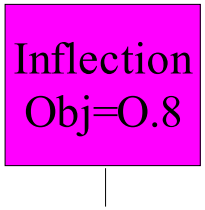


2. Latch "possible" lines for partner

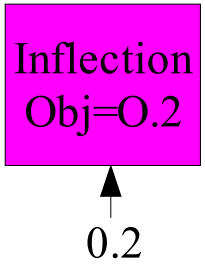


4. After several intersections start using remaining possibles

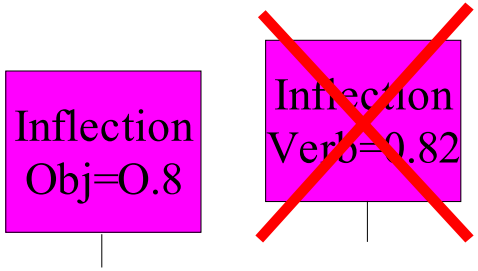
Learning Inflections



Allocate and choose random value

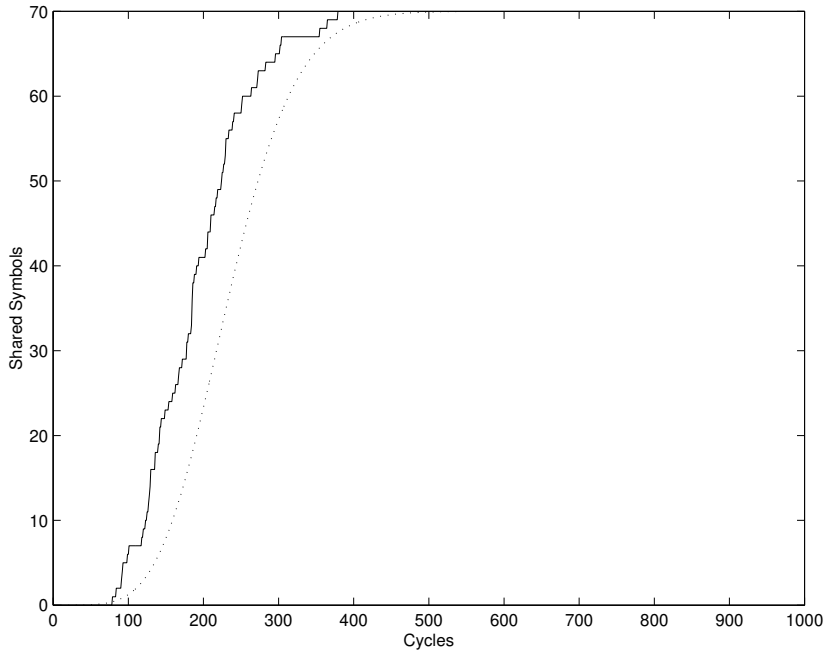


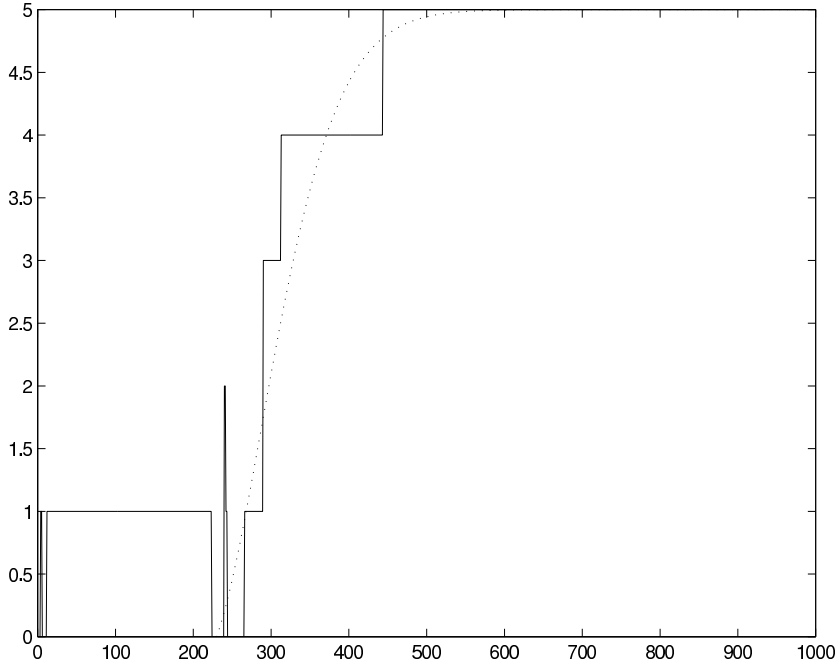
Set to value received from partner



On collision, resolve by deallocation

Learning Rate

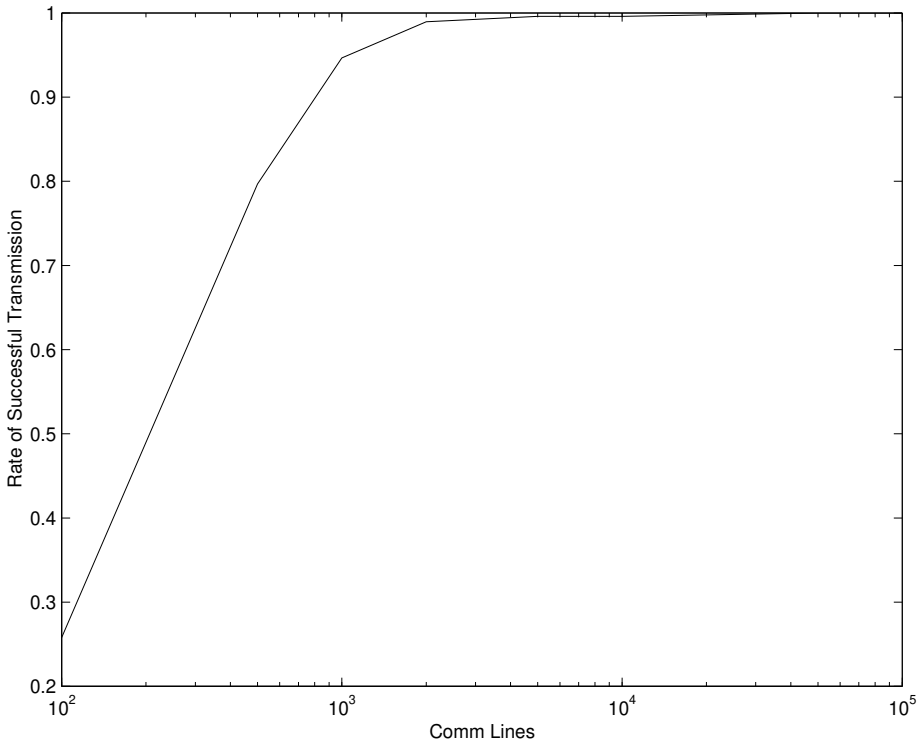




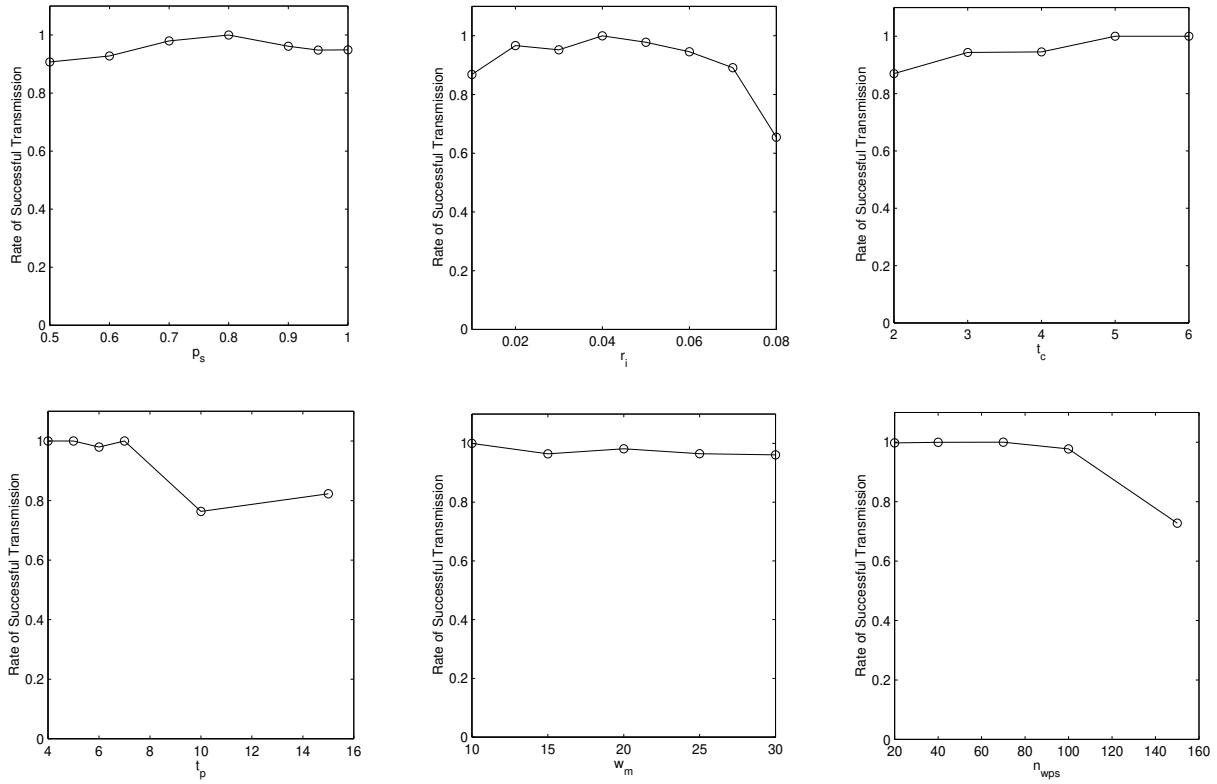
Channel Capacity

- Sparse concurrent usage → high capacity
  - 10K lines, 100 lines/word, 80% activation threshold, 6 concurrent words → 10^{12} word capacity

Robustness


Rate of Successful Transmission
Comm Lines
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
10^2
10^3
10^4
10^5

Low Sensitivity to Parameter Values



Learning From Dissimilar Views

- Words need not be equality relations!
  - Difference
  - Causality
  - Subclass/Superclass
  - Time/Space Proximity Metrics
  - Part/Whole
  - Containment
  - Attributes

Contributions

- Framed the Communication Bootstrapping problem
- Developed a fast, bidirectional solution
  - Analysis showing robustness, channel capacity, and linear learning rate
  - Experiments demonstrate analytic predictions
  - Dissimilar percepts allow other relations to be learned