# Cost & implicature in word use:

## Testing predictions of a game-theoretic model of alignment

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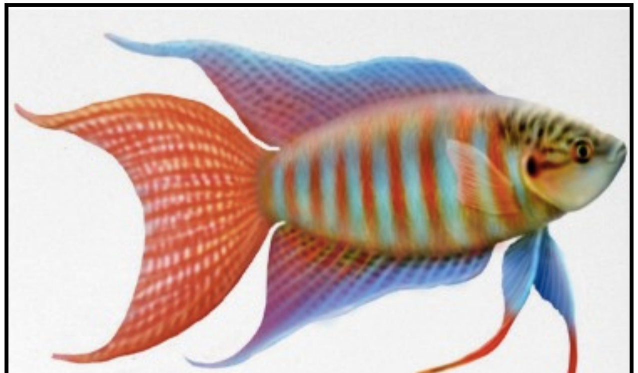
# Choice of referring expression

"fish"?

**Zebra Fish**



**Blue Paradise Fish**

**German Blue Ram Dwarf Cichlid**

# Question

- What contexts license the production and comprehension of otherwise ambiguous words?
- **Intuition**: Successful use of ambiguous words requires shared knowledge of...
  - costs
  - inferencing rules governing the communication game

# Alignment

- Joint communication tasks yield alignment
  [Garrod & Anderson, 1987; Brennan & Clark, 1996; Horton, 2008; Garrod & Pickering, 2004]
- Role of common ground in establishing convention
- Predictions regarding form~meaning mappings?
- Use contexts in which production costs are part of common ground

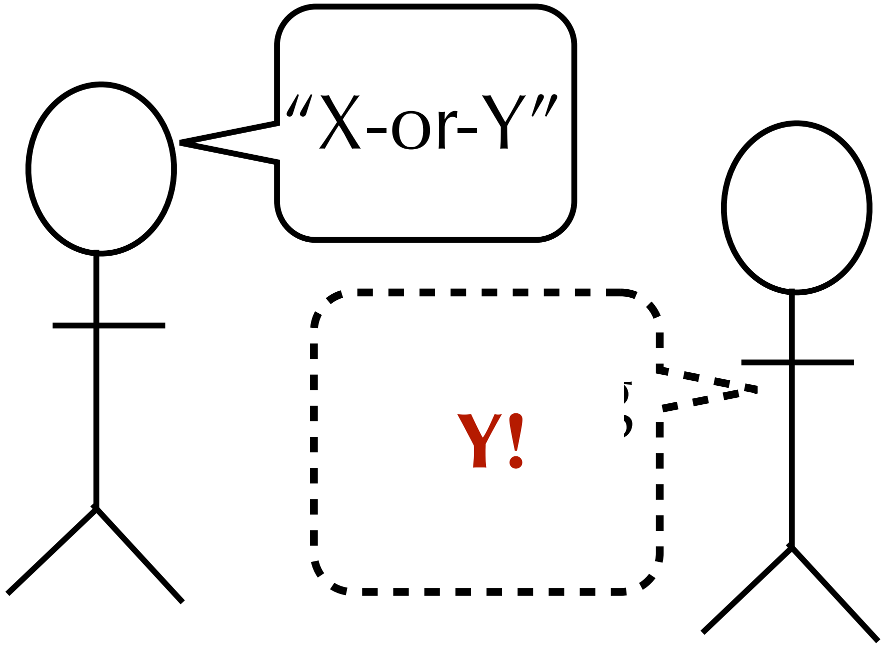
# Game Theory

- Framework for modelling strategic interaction
  [Benz, Jäger, & van Rooij, 2005]
  - Players have choices regarding behavior and preferences over possible outcomes
  - Outcomes depend on both players' choices
  - Games characterized by shared knowledge
- Prediction: ambiguous form conveys meaning if...
  - unambiguous form is costly
  - other meanings can be conveyed at low cost

# Game-theoretic prediction

**unambiguous:**
“X” ($)
“Y” ($$$)

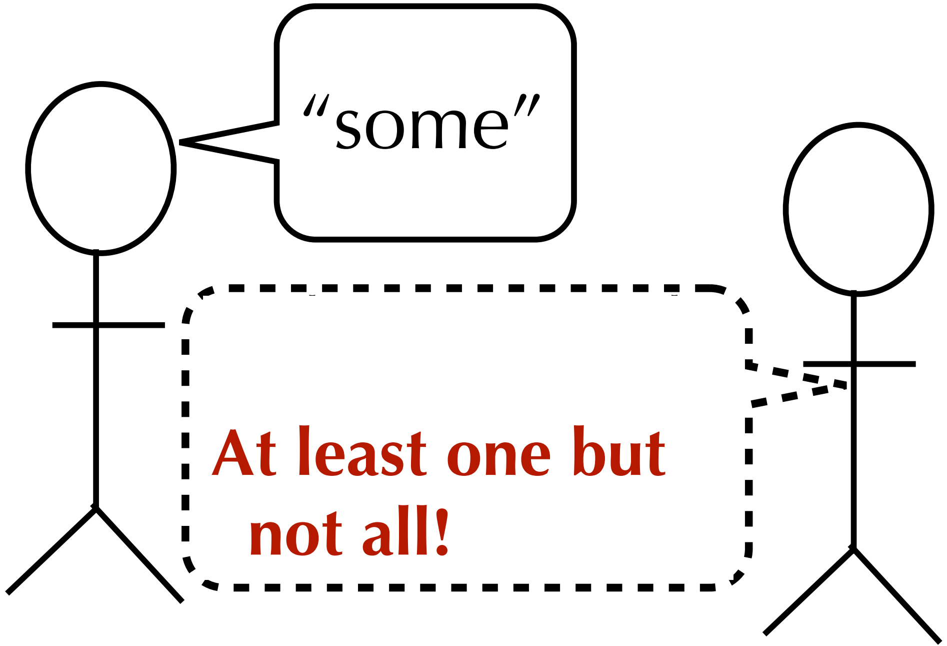
**ambiguous:**
“X-or-Y” ($)



# Conventional use of "some"

**unambiguous forms:**
"all" ($)
"at least one but not all" ($$$)

**ambiguous form**:
"some" ($)

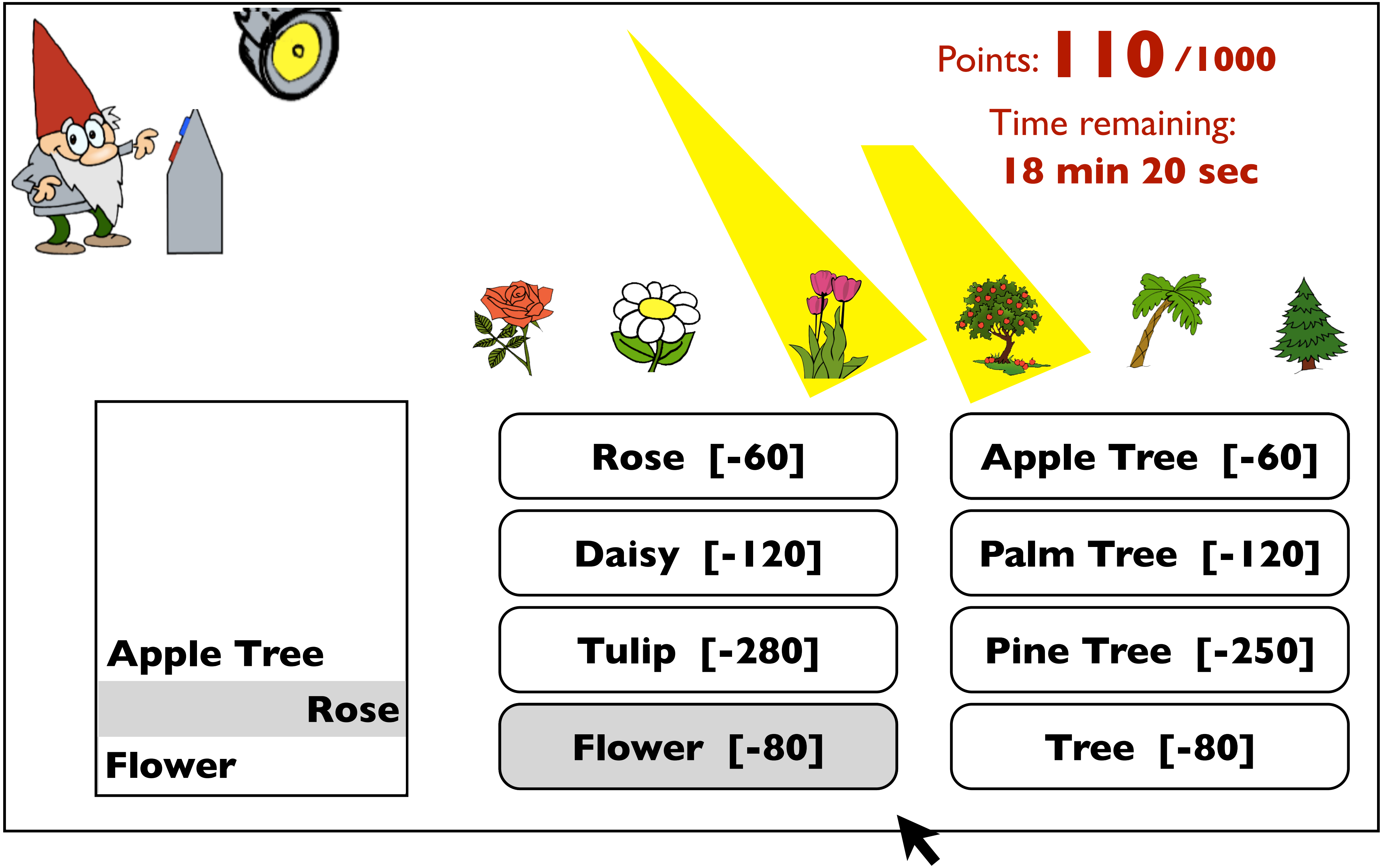



Wait, doesn't "some" just mean AT-LEAST-ONE-BUT-NOT-ALL ?

| | |
|---|---|
| **Some students came but not all of them.** | **At-least-one-but-not-all students came # but not all of them.** |
| **Some students came In fact, all students came.** | **At-least-one-but-not-all students came # In fact, all students came.** |

# Communication game

- Pairs of participants take turns as Sender & Receiver
- Goal: successful communication (hit target score)
- Word production costs points (score decreases)
- Successful comprehension yields a reward (score increase)


Points: 110 /1000
Time remaining:
18 min 20 sec
Rose [-60]
Daisy [-120]
Tulip [-280]
Flower [-80]
Apple Tree [-60]
Palm Tree [-120]
Pine Tree [-250]
Tree [-80]
Apple Tree
Rose
Flower

# Score keeping

- Game continues for 20 minutes or until either player reaches 1000 points
- Sender sees highlighted object
- Sender sends a word (Sender score decreases)

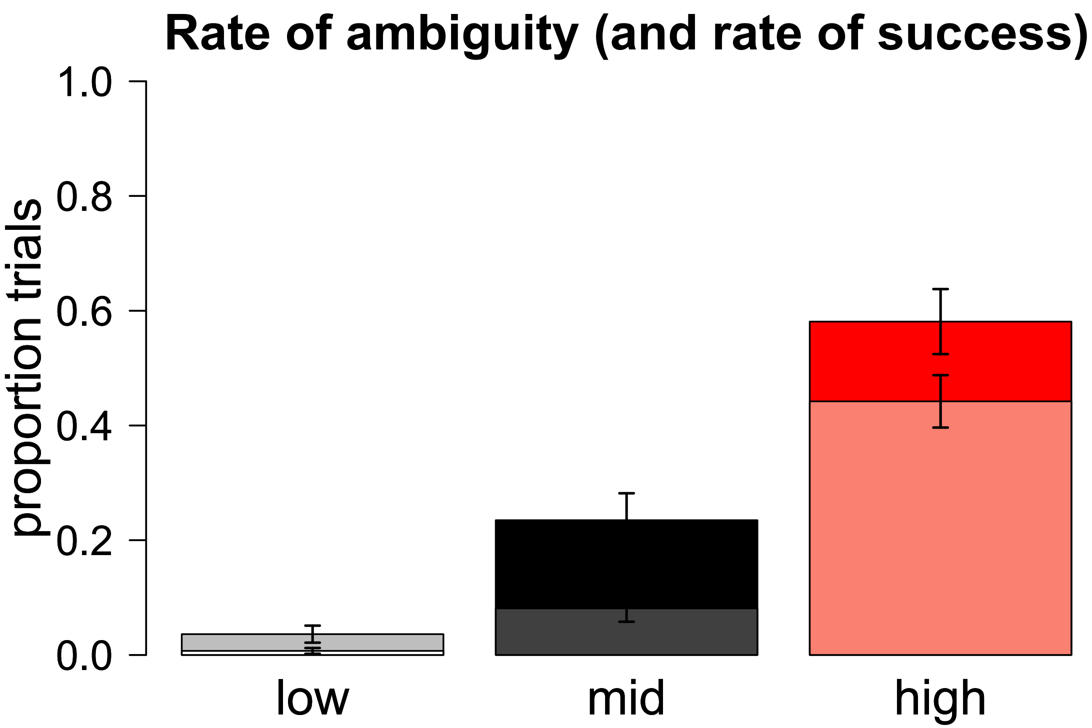
| | |
|---|---|
| "rose" | -60 |
| "daisy" | -120 |
| "tulip" | -280 |
| "flower" | -80 |

| | |
|---|---|
| "apple tree" | -60 |
| "palm tree" | -120 |
| "pine tree" | -250 |
| "tree" | -80 |

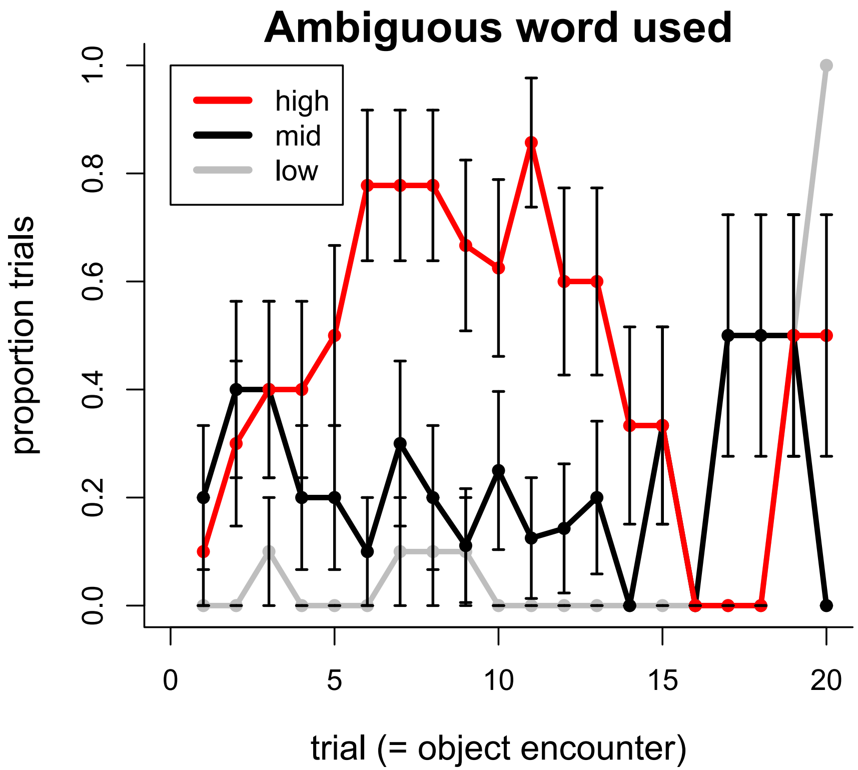
- Receiver sees word and selects an object
- If match, reward (+85 for both players)
    - Else, retry (no penalty)
- Shared knowledge of costs/rewards/scores

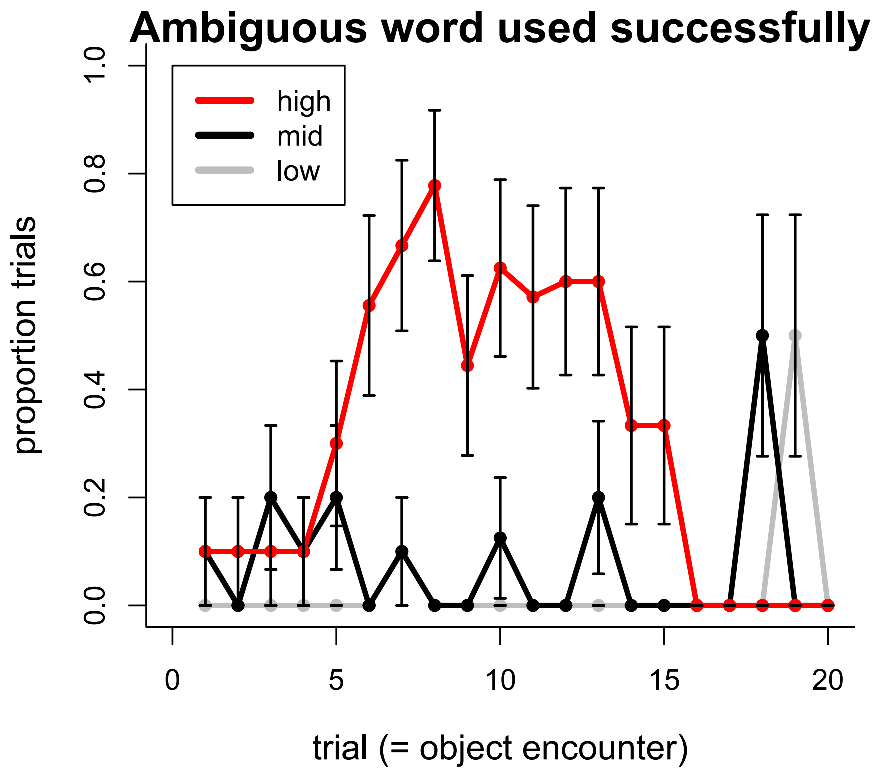
# Results

- 10 pairs:  5 success, 5 ??
- Cost influences use of ambiguous words



# Expt1: time course



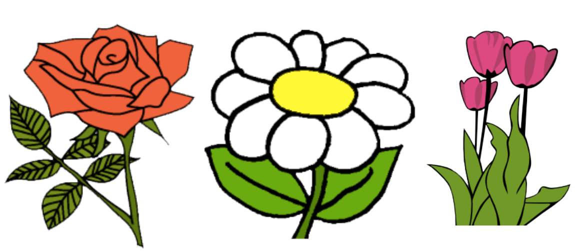



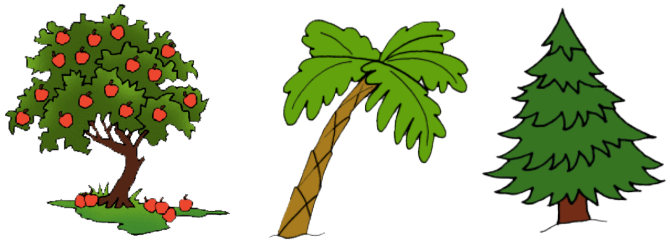

*cost
*trial#
no interaction

*cost
*trial#
no interaction

| | | | |
|---|---|---|---|
| 1 | mid | daisy | “flower” |
| 1 | mid | daisy | “daisy” |
| 2 | mid | palm | “palm tree” |
| 1 | mid | palm | “tree” |
| 1 | mid | palm | “palm tree” |
| 2 | low | apple | “apple tree” |
| 1 | mid | palm | “tree” |
| 1 | mid | palm | “palm tree” |
| 2 | mid | daisy | “flower” |
| 1 | high | tulip | “tulip” |
| 2 | low | apple | “apple tree” |
| 1 | high | pine | “pine tree” |
| 2 | high | tulip | “flower” |
| 2 | high | tulip | “flower” |
| 2 | high | tulip | “flower” |
| 1 | high | pine | “pine tree” |
| 2 | high | pine | “tree” |

# Expt2: Same method, different costs





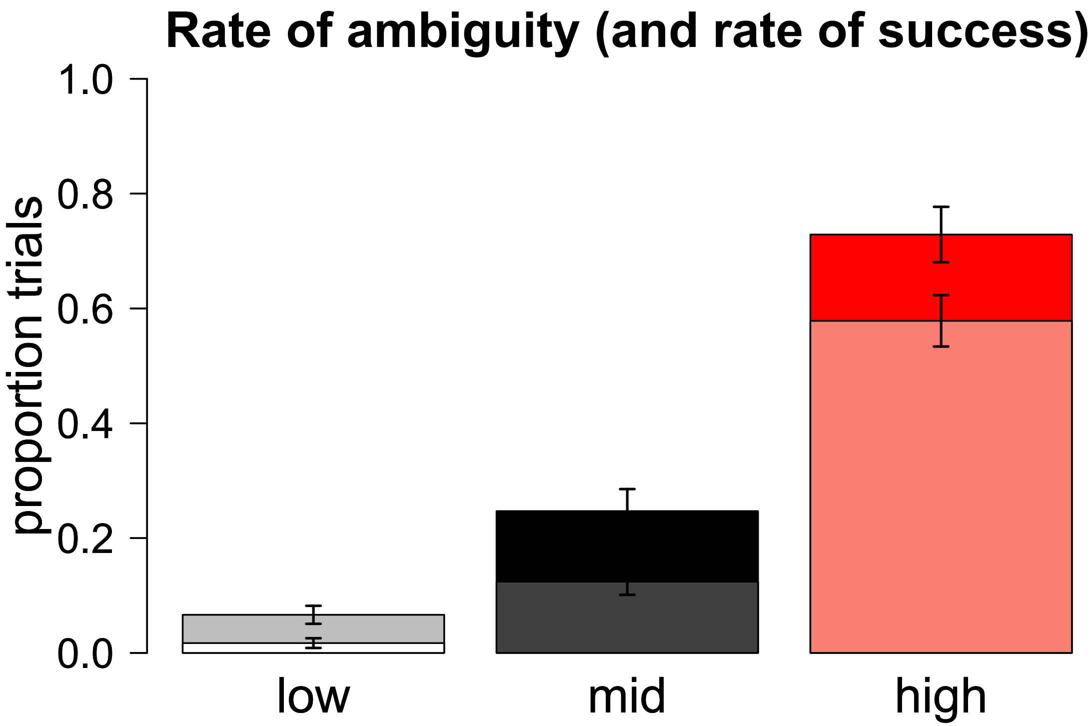
| | | Expt1 | Expt2 |
|---|---|---|---|
| LOW | “rose” | -60 | -80 |
| MID | “daisy” | -120 | -140 |
| HIGH | “tulip” | -280 | -165 |
| | “flower | -80 | -80 |

| | | Expt1 | Expt2 |
|---|---|---|---|
| LOW | “apple | -60 | -80 |
| MID | “palm tree” | -120 | -135 |
| HIGH | “pine tree” | -250 | -170 |
| | “tree” | -80 | -80 |

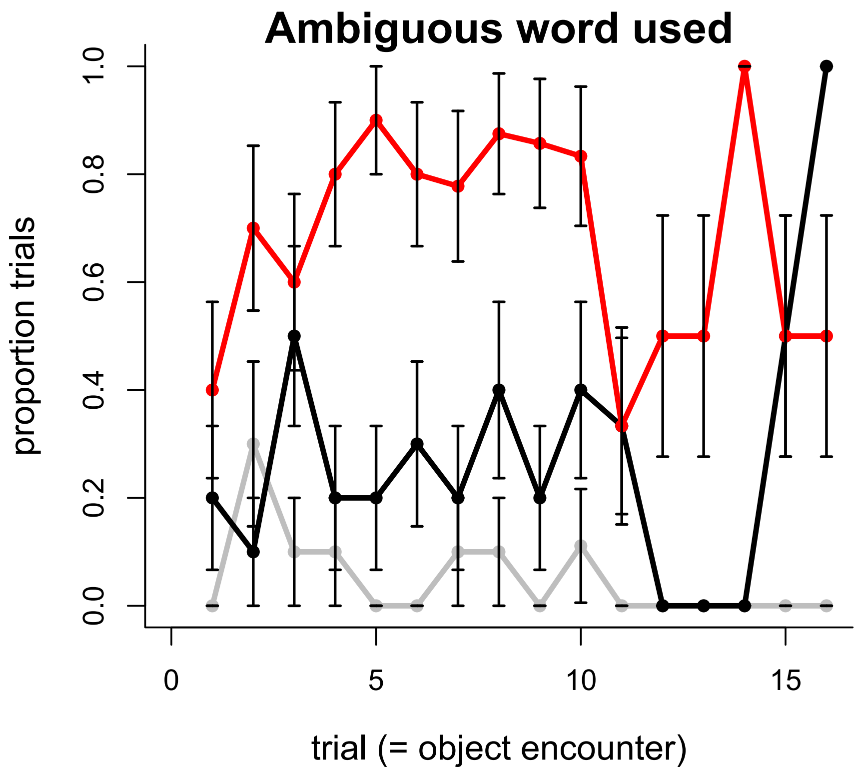
- Impact of lower costs? With same reward for a match,
  - Expt2 imposes lower costs, easier to hit target score
  - Reduced motivation to conventionalize?

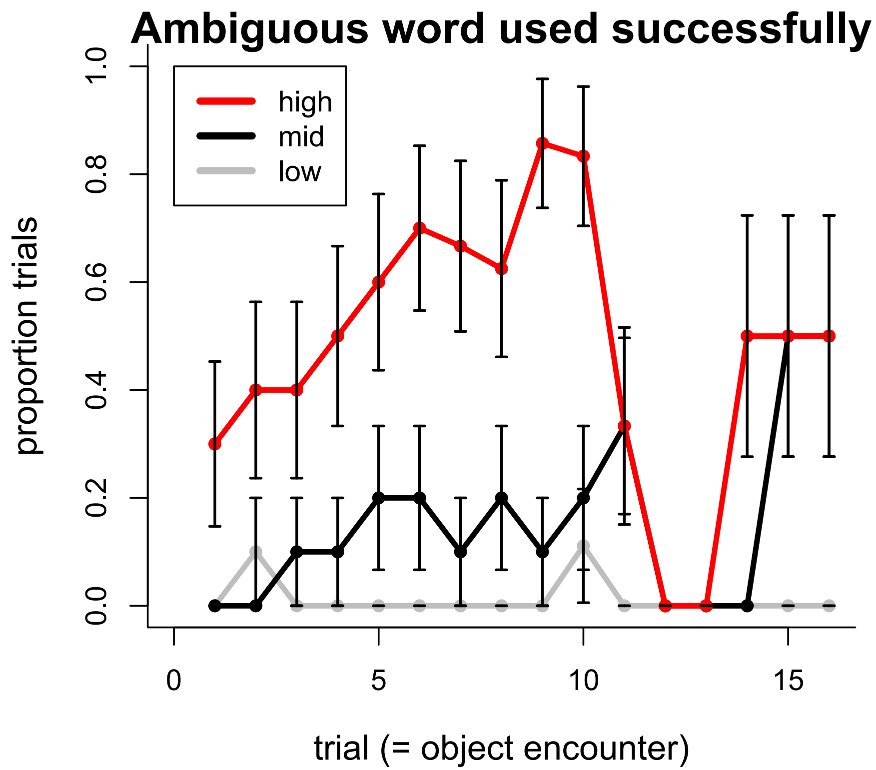
# Expt2: Results

- 10 pairs: 8 success, 2 ??
- As in Expt1, cost influences production and comprehension of ambiguous words



# Expt2: Time course




*cost
no trial# effect
no interaction

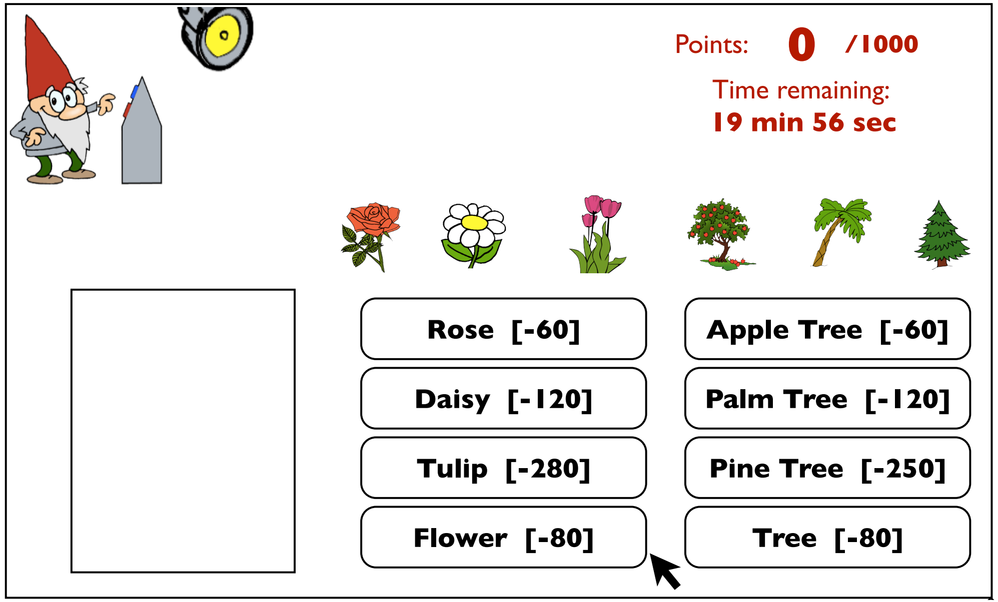
*cost
*trial#
no interaction

# Comparison of Expt1/Expt2

- As in Expt1, Expt2 showed a main effect of cost.
- However, Expt2 also led to greater use of ambiguous words.
- As in Expt1, ambiguity in Expt2 led to successful communication, but...
  - 2 pairs assigned ambiguous word to object with mid-cost unambiguous name
  - 2 pairs used ‘tree’ but not ‘flower’

# Inference or trial-and-error?

- **Post-hoc analysis:** Consider first trial where ambiguous word (“flower”, “tree”) was used
- **Finding:** Receivers guessed, more often than chance, that the intended object was the high-cost object.



# Summary

- **Beyond some/all:** Ambiguous words can be used reliably for entities with costly unambiguous names, if other referents have low-cost unambiguous names.
- **Sensitivity to cost:** More ambiguous words in contexts where unambiguous names have more similar costs.
- **Speaker's thoughts about the listener:** Is choice of referring expression automatic/strategic? [Horton 2008]
- **Role of reduction:** Speakers make rational decisions about redundancy and reduction. [see also Genzel & Charniak, 2002; Jaeger 2010; Levy & Jaeger 2007; Piantadosi, Tily, & Gibson, 2011]
- **Claim:** Ambiguity arises from a rational process of communication, specifically when cost is part of speakers' shared common ground.

Thanks!