

# Word Games

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# Dialogue

- ▶ Communication is rarely unambiguous
  - ▶ Ambiguity resolution through dialogue
  - ▶ Clarification questions
- ▶ Interactive, symmetric reference games
  - ▶ Isolates ambiguity resolution
  - ▶ Both give and request information

# Games

Friends of agent A:

Name	School	Major	Company
Jessica	Columbia	Computer Science	Google
Josh	Columbia	Linguistics	Google
...	...	...	...

A: Hi! Most of my friends work for Google

B: do you have anyone who went to columbia?

A: *Hello?*

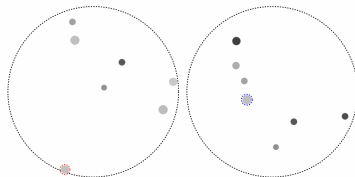
A: I have Jessica a friend of mine

A: and Josh, both went to columbia

B: *or anyone working at apple?*

B: SELECT (Jessica, Columbia, Computer Science, Google)

A: SELECT (Jessica, Columbia, Computer Science, Google)



Human A's view      Human B's view

Human B: three light grey dots in a diagonal line

Human A: i dont have that but i have a black dot neer the top to the right, the only black dot in the circle

Human B: i have two black dots. find something else

Human A: ok i have a light grey dot by itself at the bottom to the left. right on the line

Human B: how big is it

Human A: its one of the bigger ones

Human B: okay just pick it then

Human A: ok

Human B: SELECT blue

Human A: SELECT red

## Mutual Friends and OneCommon

## Issue: Poor neural reasoning

From Mutual Friends: Neural + Human

- ▶ A: Know anyone who likes chess?
- ▶ B: None of my friends like chess.
- ▶ (conversation continues)
- ▶ A: Crocheting?
- ▶ B: None like crocheting.
- ▶ A: Chess?
- ▶ B: None like chess either, haha.

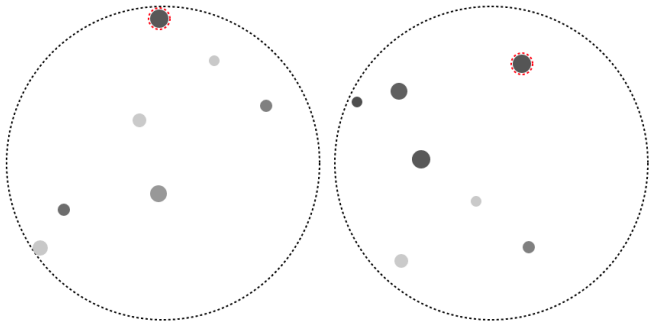
# Issue: Poor neural reasoning



Agent 0: human || 1: human

0	1
0	1 I see a large grey dot with a smaller black dot right below it
1	0 is the smaller black dot to the right and below
2	1 No, it is slightly to the left and below
3	0 Might not be the same one. Do you have a lot of dots in a fairly vertical conformation
4	1 I have three dots in a kinda vertical line with different shade of gray but close in size
5	0 Is the middle dot curved to the left or right a little bit?
6	1 the middle dot is slightly to the left of the other two and is also a little bit darker than the rest
7	0 Yes pick that middle dot

# Issue: Poor neural reasoning



Agent 0: pragmatic\_confidence || 1: human

	0	1
0	0	i have one large black dot by itself . do you have it ?
1	1	Yes, I do have that.
2	0	let 's pick that one
3	1	ok
4	0	ok

## Issue: Scaling rule-based

System	$C$	$C_T$	$C_S$
Human	.89	.07	.36
Rule	<b>.88</b>	<b>.06</b>	<b>.29</b>
StanoNet	.76	.04	.23
DynoNet	.87	.05	.27

- ▶ Rule-based text generation and understanding is viable for Mutual Friends
- ▶ Continuous and spatial nature of OneCommon makes writing rules difficult

## Current approaches: Two extremes

- ▶ Neural encoder-decoder
  - ▶ Encode past interactions with a neural net
  - ▶ Generate what to say with a neural net
  - ▶ Brittle strategy, less brittle language
- ▶ Rule-based
  - ▶ Encode past interactions in a table
  - ▶ Use rules for what to say next
  - ▶ Nonparametric lookup of utterances
  - ▶ Brittle language, less brittle strategy
- ▶ Meet in middle with interpretable planning + neural language



# A dialogue turn

- ▶ Engaging in dialogue requires
  - ▶ Inference: What do I know? How do I represent it?
  - ▶ Planning: What should I do and say?
- ▶ Formulate as model-based optimization
  - ▶ Plan what to say through a simple model of our partner
  - ▶ Model of partner conditions on past information

# Problem setup

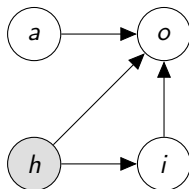
- ▶ Goal: Mutually select the same item as partner
  - ▶ Row in knowledge base, dot
  - ▶ Coordinate through dialogue
- ▶ Given history  $h$ , we need to choose an action  $a$  by optimizing value

$$\max_a V(h, a)$$

- ▶ How should we define value  $V$ ?
- ▶ How do we represent  $h, a$ ?

## Value: Information Gain

- ▶ A good action should move us closer to game success
- ▶ Game success depends on our knowledge of our partner's context
- ▶ Requires
  - ▶ Belief distribution over selection item given history  $p(i | h)$
  - ▶ Partner response model  $p(o | h, a, i)$
- ▶ Represent a turn as



## Value: Information Gain

- ▶ Picture would be much better here...
- ▶ Value = expected information gain

$$IG(h, a) = H(i \mid h) - \mathbb{E}_{p(o|h,a)} [H(i \mid h, a, o)]$$
$$\mathbb{E}_{p(o|h,a)} [H(i \mid h, a)] = \sum_o \sum_{i'} p(o \mid h, a, i) p(i \mid h) H(i \mid h, a, o)$$

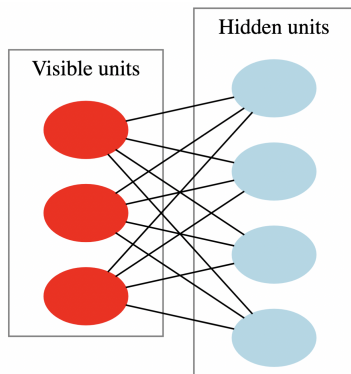
- ▶ Equivalent to minimizing expected uncertainty after receiving a response
- ▶ Cite Yu et al, White et al

# Issues with information gain

- ▶ Too much burden on the obs model  $p(o \mid h, a, i)$ 
  - ▶ When  $o$  is natural language, conditioning on  $h$  is important
  - ▶ If we had a great obs model, would we really have issues with solving these simple dialogue games?
- ▶ Proposal: Set up models for success by separating language from strategy
  - ▶ Rule-based representations good for strategy
  - ▶ Neural models good for language
- ▶ Set up so that  $o \perp\!\!\!\perp h \mid a, i$  is a reasonable assumption
- ▶ Reframe dialogue as 'asking about features' for item selection
- ▶ Convert language to and from features

# State and belief

- ▶ History: whether features have been asked  $h \in \{0, 1\}^N$
- ▶ Items:  $i \in [M]$ ,  $N \gg M$
- ▶  $p(i | h) = \frac{\sum_n \psi(h_n, i)}{\sum_{i', n} \psi(h_n, i')}$
- ▶  $p(i | h) \propto 1 + \log 1 + \sum_n \psi(h_n, i)$
- ▶  $\psi(h_n, i) = w_n 1(h_n(i))$



End

# Concerns

- ▶ Would a large LM solve all of this?
  - ▶ Fine tune on small onecommon dataset, are there still repeats?
  - ▶ Unlikely to solve strategy / over optimism



End

# Citations I