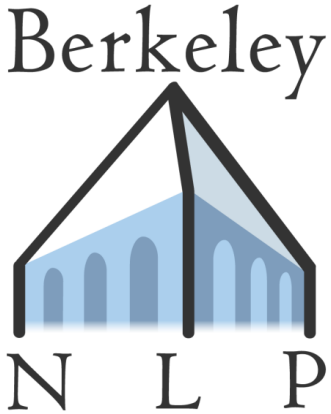
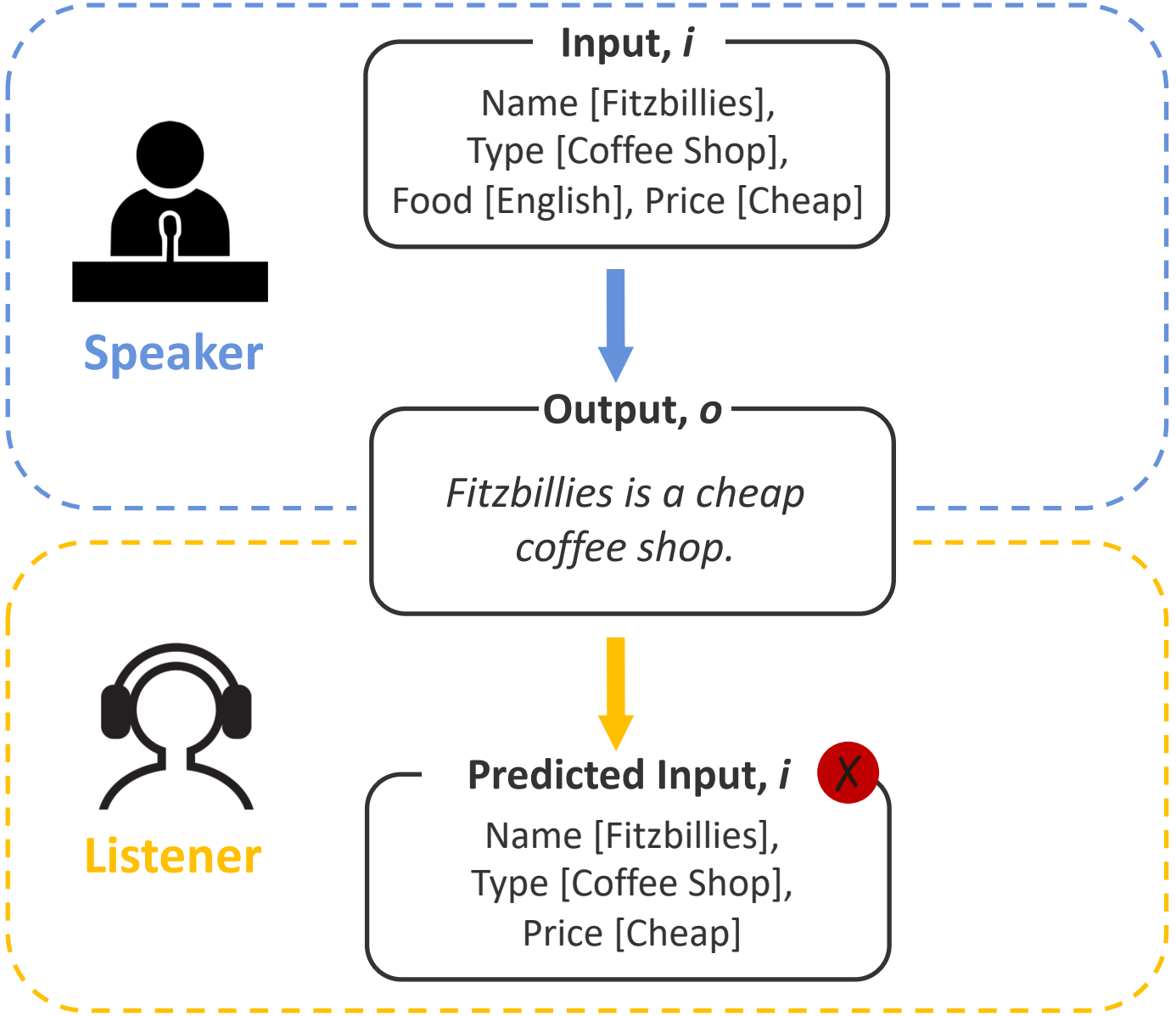
Pragmatically Informative Text Generation

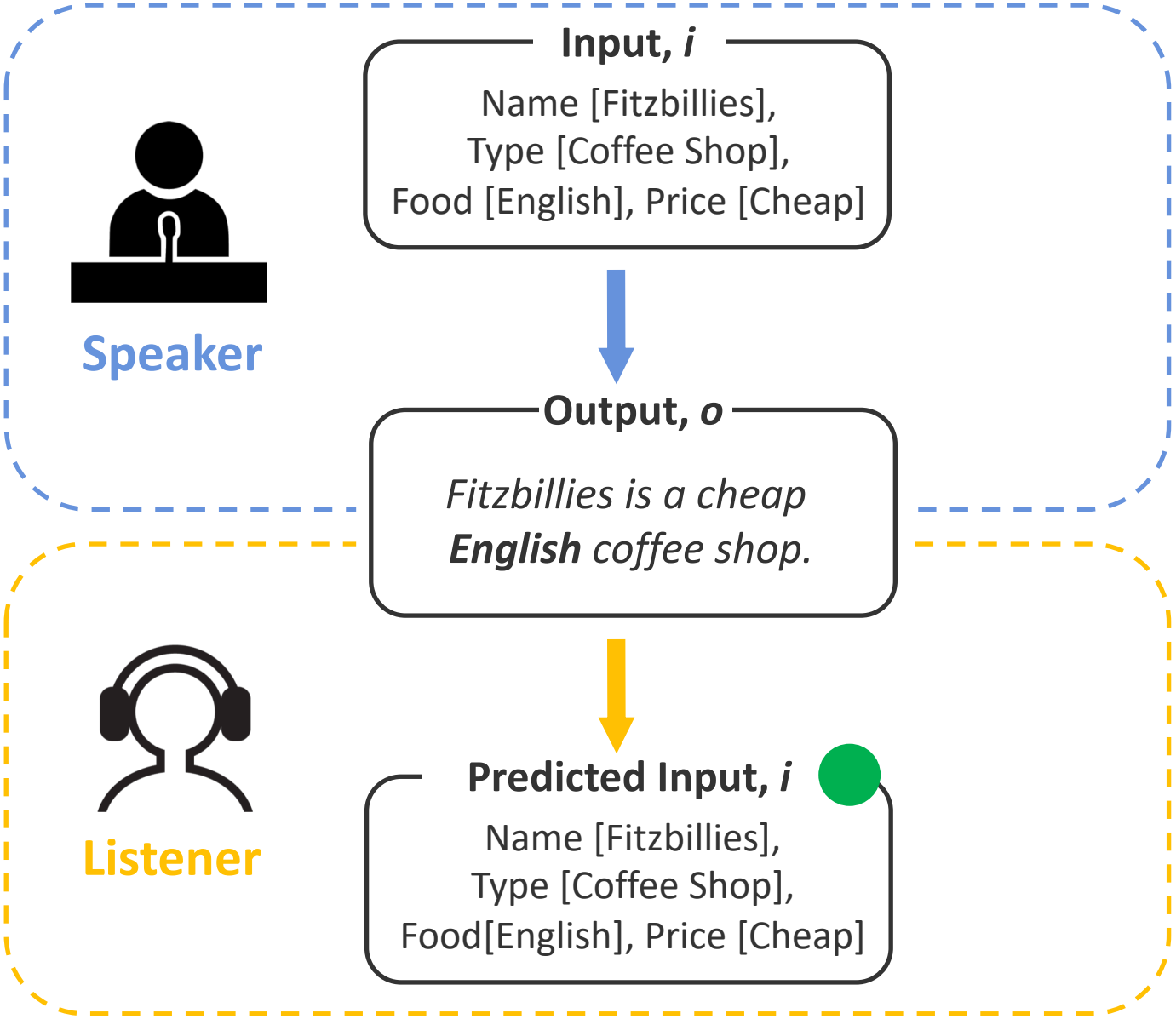


Sheng Shen, Daniel Fried, Jacob Andreas, and Dan Klein

Why Might Generation Need Pragmatics?



Why Might Generation Need Pragmatics?



Generation as a Pragmatic Game

Speaker

Input, *i*

Name [Fitzbillies],
Type [Coffee Shop],
Food [English], Price [Cheap]

Output, *o*

Fitzbillies is a cheap coffee shop.

Output, *o*

*Fitzbillies is a cheap **English** coffee shop.*

Listener

Predicted Input, *i* ✗
Name [Fitzbillies],
Type [Coffee Shop],
Price [Cheap]

Predicted Input, *i* ✗
Name [Fitzbillies],
Price [Cheap]

Predicted Input, *i* ●
Name [Fitzbillies],
Type [Coffee Shop],
Food [English], Price [Cheap]

Predicted Input, *i* ✗
Name [Fitzbillies],
Type [Coffee Shop],
Price [Cheap]

Generation as a Pragmatic Game

Speaker

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Name [Fitzbillies],
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Output, *o*

Fitzbillies is a cheap coffee shop.

Output, *o*

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Listener

Predicted Input, *i*
Name [Fitzbillies],
Type [Coffee Shop],
Price [Cheap]

Predicted Input, *i*
Name [Fitzbillies],
Price [Cheap]

Predicted Input, *i*
Name [Fitzbillies],
Type [Coffee Shop],
Food [English], Price [Cheap]

Predicted Input, *i*
Name [Fitzbillies],
Type [Coffee Shop],
Price [Cheap]

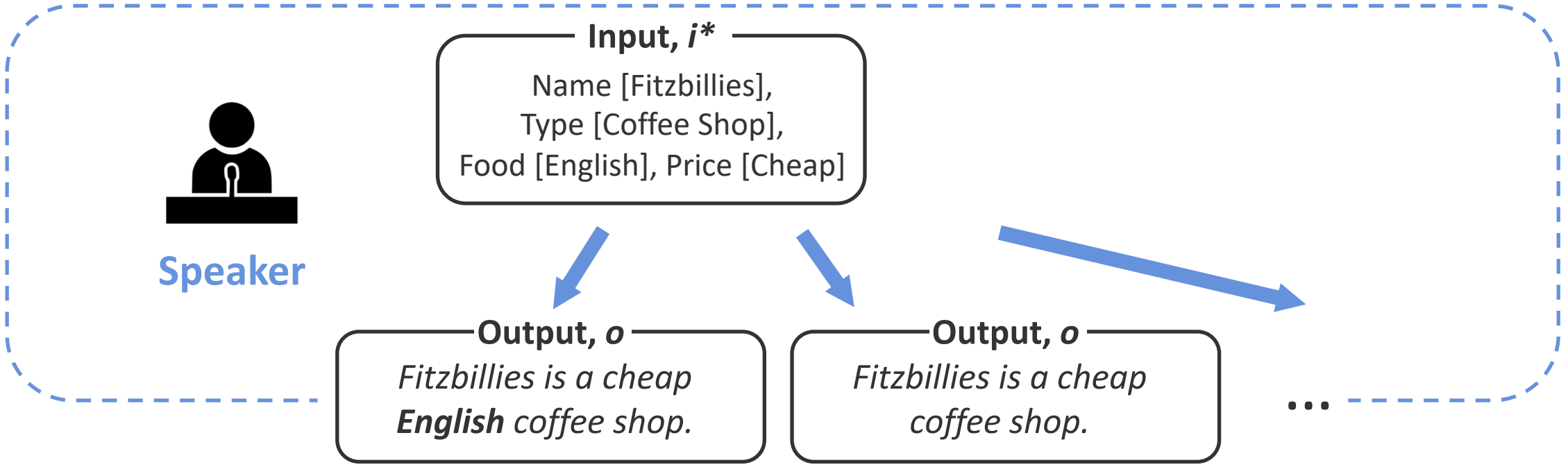
Generating Pragmatic Output Text

Speaker

Input, *i

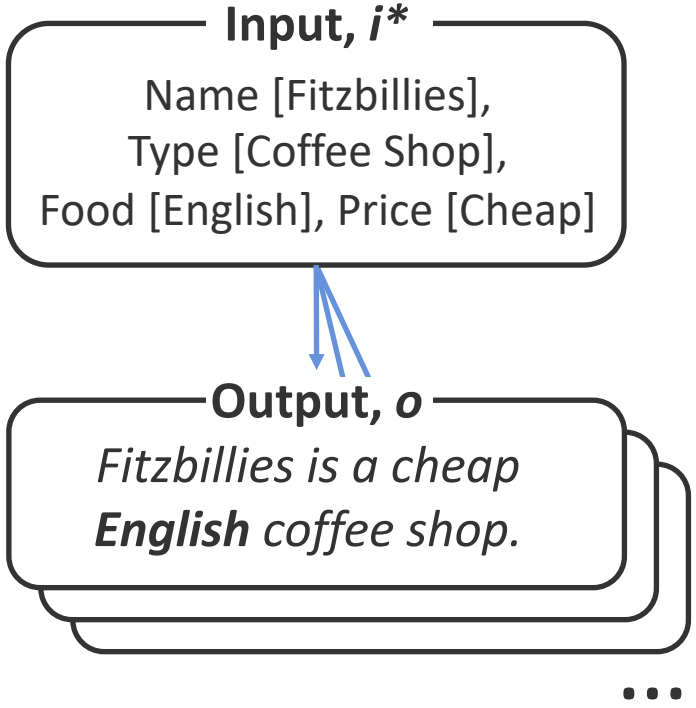
Name [Fitzbillies],
Type [Coffee Shop],
Food [English], Price [Cheap]

Generating Pragmatic Output Text



Generating Pragmatic Output Text

Speaker



Searching:
Search over possible outputs *o,* using candidates from a standard seq-to-seq speaker model

Generating Pragmatic Output Text

Speaker

Input, *i

Name [Fitzbillies],
Type [Coffee Shop],
Food [English], Price [Cheap]

Output, *o*

Fitzbillies is a cheap ***English*** *coffee shop.*

Searching:
Search over possible outputs *o,* using candidates from a standard seq-to-seq speaker model

Listener
P(i |o)

Predicted Input, *i*
Name [Fitzbillies],
Type [Coffee Shop],
Food [English], Price [Cheap]

Predicted Input, *i*
Name [Fitzbillies],
Type [Coffee Shop],
Price [Cheap]

...

Generating Pragmatic Output Text

Speaker

Input, *i

Name [Fitzbillies],
Type [Coffee Shop],
Food [English], Price [Cheap]

Output, *o*

Fitzbillies is a cheap ***English*** *coffee shop.*

...

Searching:
Search over possible outputs *o,* using candidates from a standard seq-to-seq speaker model

Listener
P(i |o)

Predicted Input, *i*

Name [Fitzbillies],
Type [Coffee Shop],
Food [English], Price [Cheap]

...

Scoring:
Choose an output with maximum listener probability, ***P(i* | o)***

How to Construct the Listener?

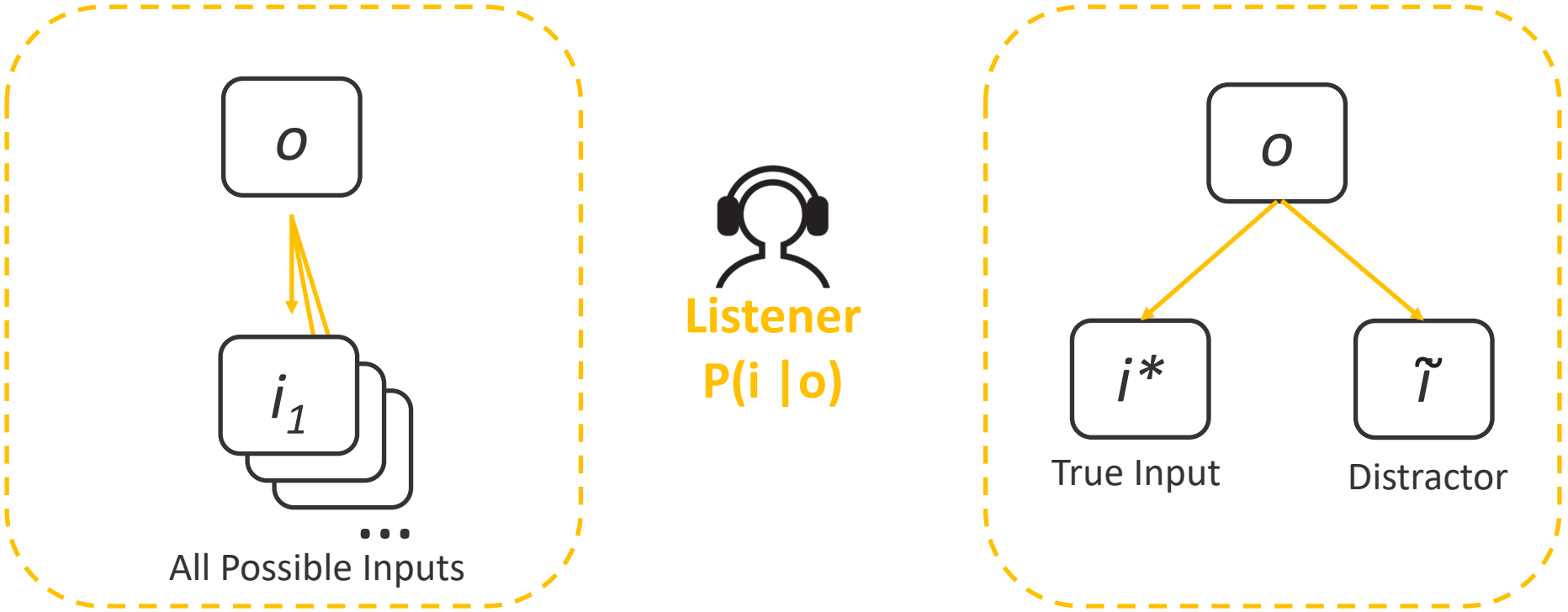
Reconstructor-Based

Train a separate **Listener** model to give a distribution over any possible inputs.

or

Distractor-Based

Construct a context-appropriate *distractor* input that **Listener** needs to distinguish the true input from.



Past Work on Pragmatic Generation

Convey All Relevant Info

[Grice 1970, Horn 1984,
Dušek and Jurčíček 2016,
Li et al. 2016,
He et al. 2016,
Fried et al. 2018,
Cohn-Gordon et al. 2019, ...]

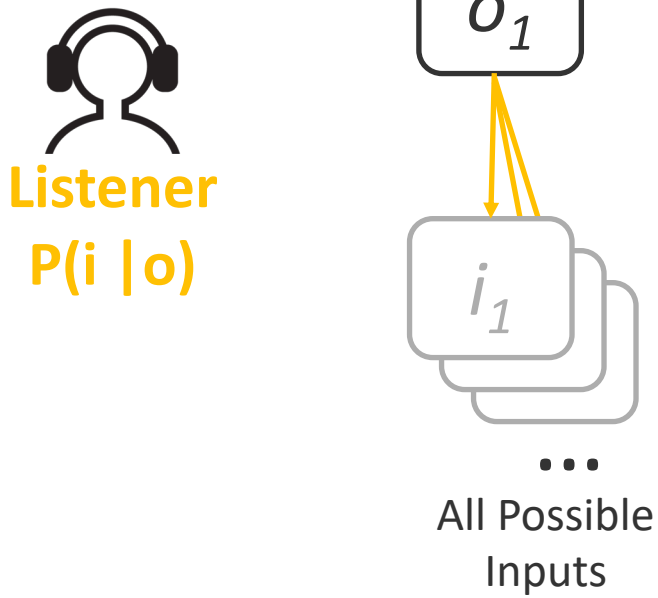
Motivates Reconstructor

Be Informative in Context

[Golland et al. 2010,
Frank and Goodman 2012,
Mao et al. 2015,
Andreas and Klein 2016,
Vedantam et al. 2018,
Cohn-Gordon et al. 2018, …]

Motivates Distractor

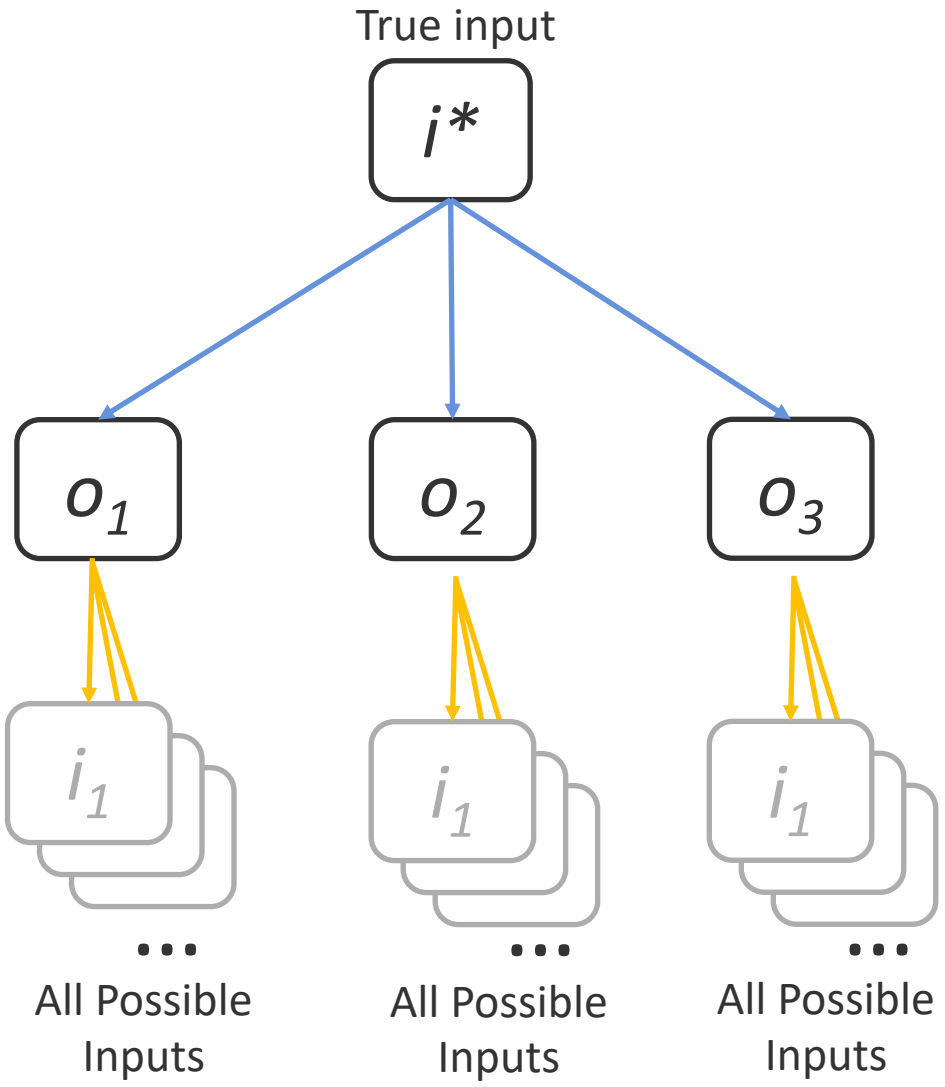
Reconstructor-Based Pragmatics



Reconstructor-Based Pragmatics

Speaker
P(o | i*)

Listener
P(i |o)

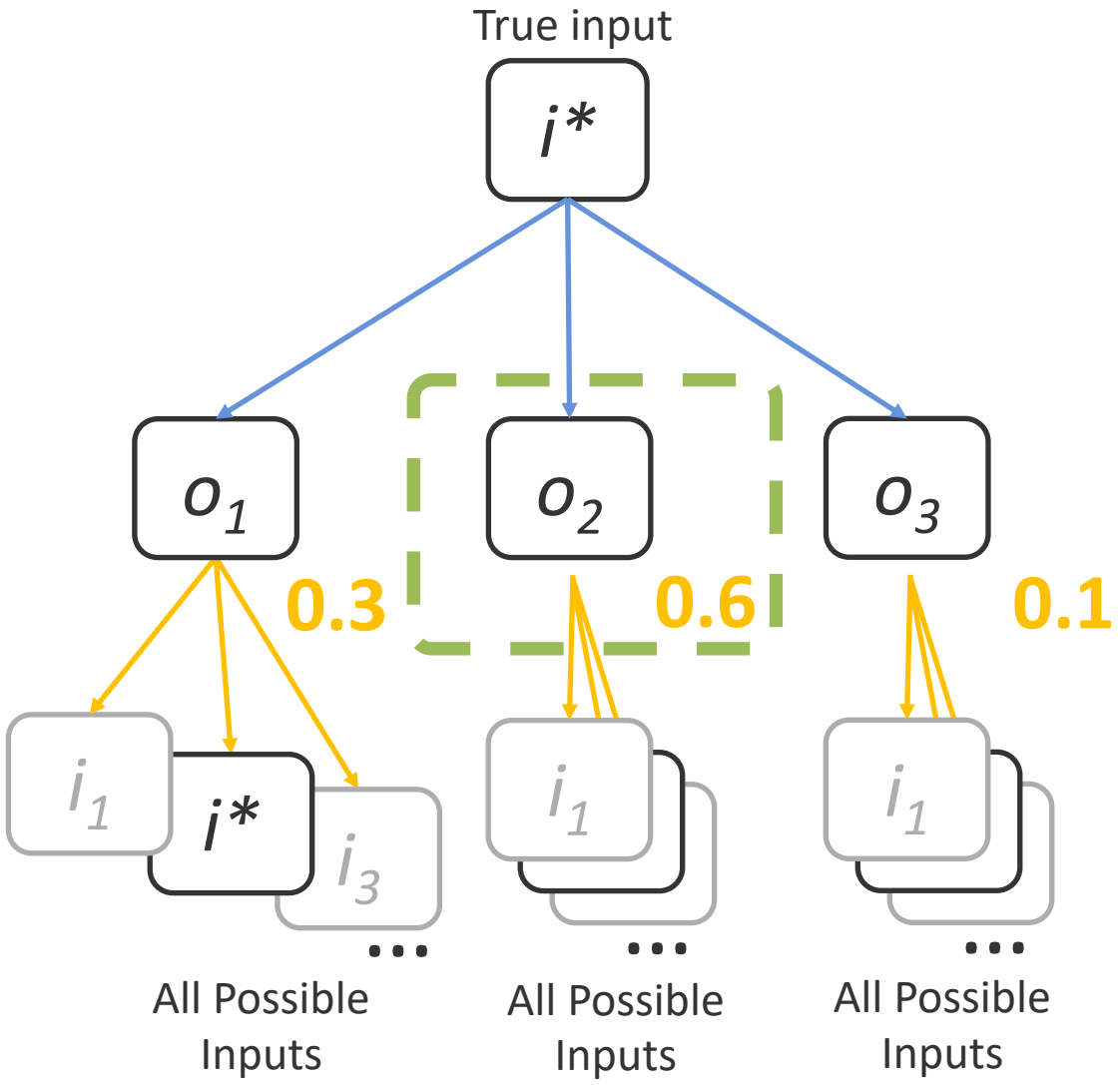


Searching:
Obtain candidate outputs by beam search in **P(o | i*)**

Reconstructor-Based Pragmatics

Speaker
P(o | i*)

Listener
P(i |o)

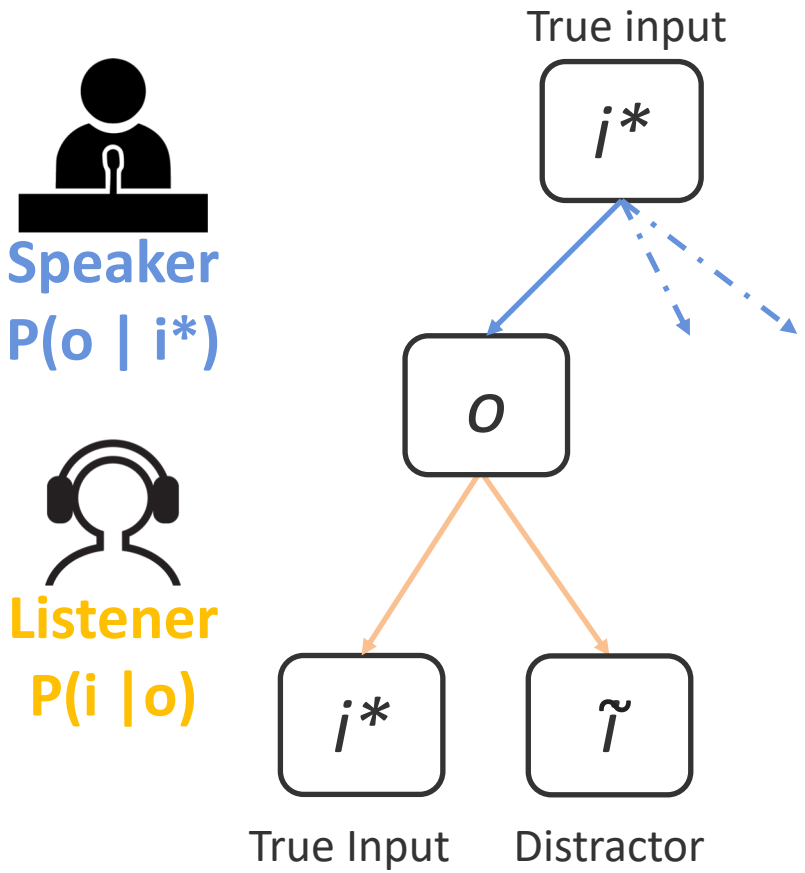


Searching:
Obtain candidate outputs by beam search in **P(o | i*)**

Scoring:
Score and select o using **P(i* | o)**

Distractor-Based Pragmatics

When we use a Listener can only produce the true input and a distractor, we can define the Listener using the Speaker and Bayes' rule:



Searching:
Obtain candidate outputs by beam search in **P(o | i*)**

Given by seq-to-seq Speaker

Use a uniform prior

$$P(i^*|o) = \frac{P(o|i^*)P(i^*)}{\sum_{i' \in \{i^*, \tilde{i}\}} P(o|i')P(i')}$$

Scoring:
Choose output by argmax_o **P(i* | o)**

Distractor-Based Pragmatics

$$P(i^*|o) = \frac{P(o|i^*)}{\sum_{i' \in \{i^*, \tilde{i}\}} P(o|i')}$$

Possible Outputs
(search over these)

o_1: *Fitzbillies is a cheap coffee shop.*

o_2: *Fitzbillies is a cheap **English** coffee shop.*

...

Inputs

True Input, i^*
Name [Fitzbillies],
Eat Type [Coffee Shop],
Food[English], Price[Cheap]

0.4 0.2 ...

Distractor, $\tilde{i}$
Name [Fitzbillies],
Eat Type [Coffee Shop],
Price[Cheap]

0.8 0.05 ...

Distractor-Based Pragmatics

$$P(i^*|o) = \frac{P(o|i^*)}{\sum_{i' \in \{i^*, \tilde{i}\}} P(o|i')}$$

Possible Outputs
(search over these)

	o_1	o_2	
	Fitzbillies is a cheap coffee shop.	*Fitzbillies is a cheap **English** coffee shop.*	...
Inputs			
True Input, i^* Name [Fitzbillies], Eat Type [Coffee Shop], Food[English], Price[Cheap]	0.33	**0.8**	...
Distractor, $\tilde{i}$ Name [Fitzbillies], Eat Type [Coffee Shop], Price[Cheap]	**0.66**	0.2	...

Distractor-Based Pragmatics

$$P(i^*|o) = \frac{P(o|i^*)}{\sum_{i' \in \{i^*, \tilde{i}\}} P(o|i')}$$

Possible Outputs

(search over these)

o_1

Fitzbillies is a cheap coffee shop.

o_2

*Fitzbillies is a cheap **English** coffee shop.*

...

Inputs

True Input, i^*

Name [Fitzbillies], Eat Type [Coffee Shop], Food[English], Price[Cheap]

Distractor, $\tilde{i}$

Name [Fitzbillies], Eat Type [Coffee Shop], Price[Cheap]

0.33 **0.8** ...

Choose argmax o as the pragmatic output!

0.66 **0.2** ...

In practice: do the search and normalization incrementally, word-by-word. [Cohn-Gordon et al. 2018.]

Generation from Meaning Representations

Input:

```
Name[Fitzbillies],

EatType[Coffee Shop],

PriceRange[Cheap],

Area[Riverside],

Food[English]
```

Seq-to-Seq Speaker

lexicalization

[Puzikov and Gurevych, 2018]

Output:

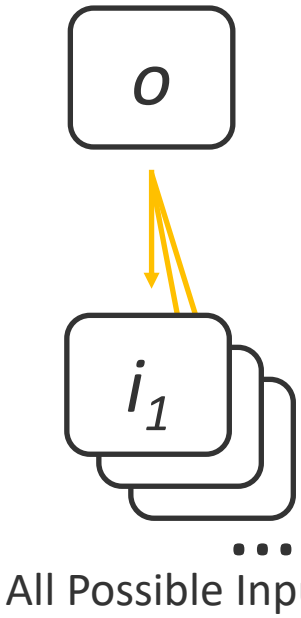
O

Fitzbillies is a coffee shop that serves English food. It is located in riverside area.

Generation from Meaning Representations

Reconstructor:

S^R (a multi-task classifier) maps each output to input.

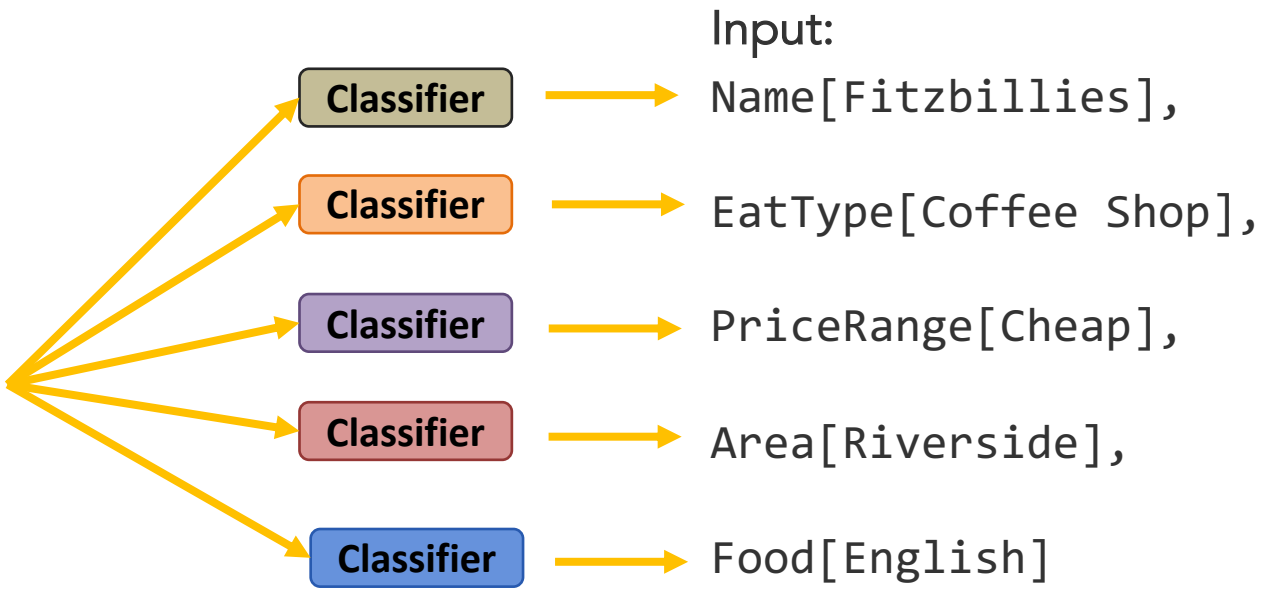


All Possible Inputs

Fitzbillies is a coffee shop that serves English food. It is located in riverside area.

Listener

P(i* |o)

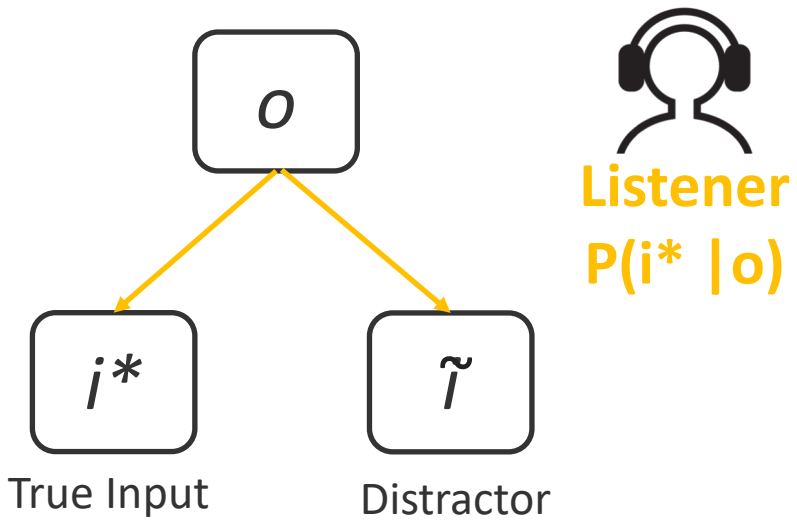


Generation from Meaning Representations

Distractor:

S^D is based on the MR that masks out other attributes.

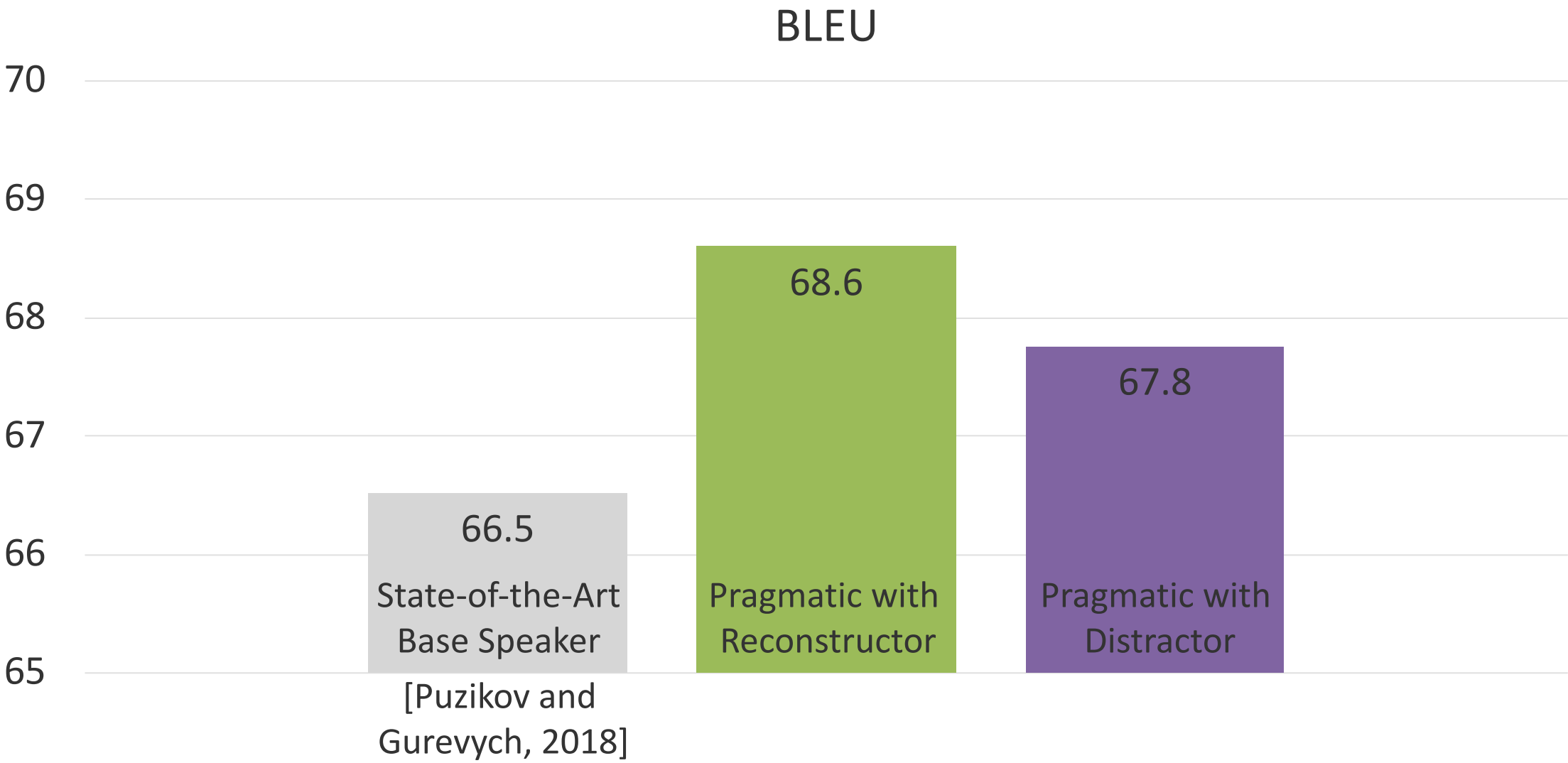
Eg: Near[Burger King]



Input:

```
Name[Fitzbillies],

EatType[Coffee Shop],

PriceRange[Cheap],

Area[Riverside],

Food[English]
```

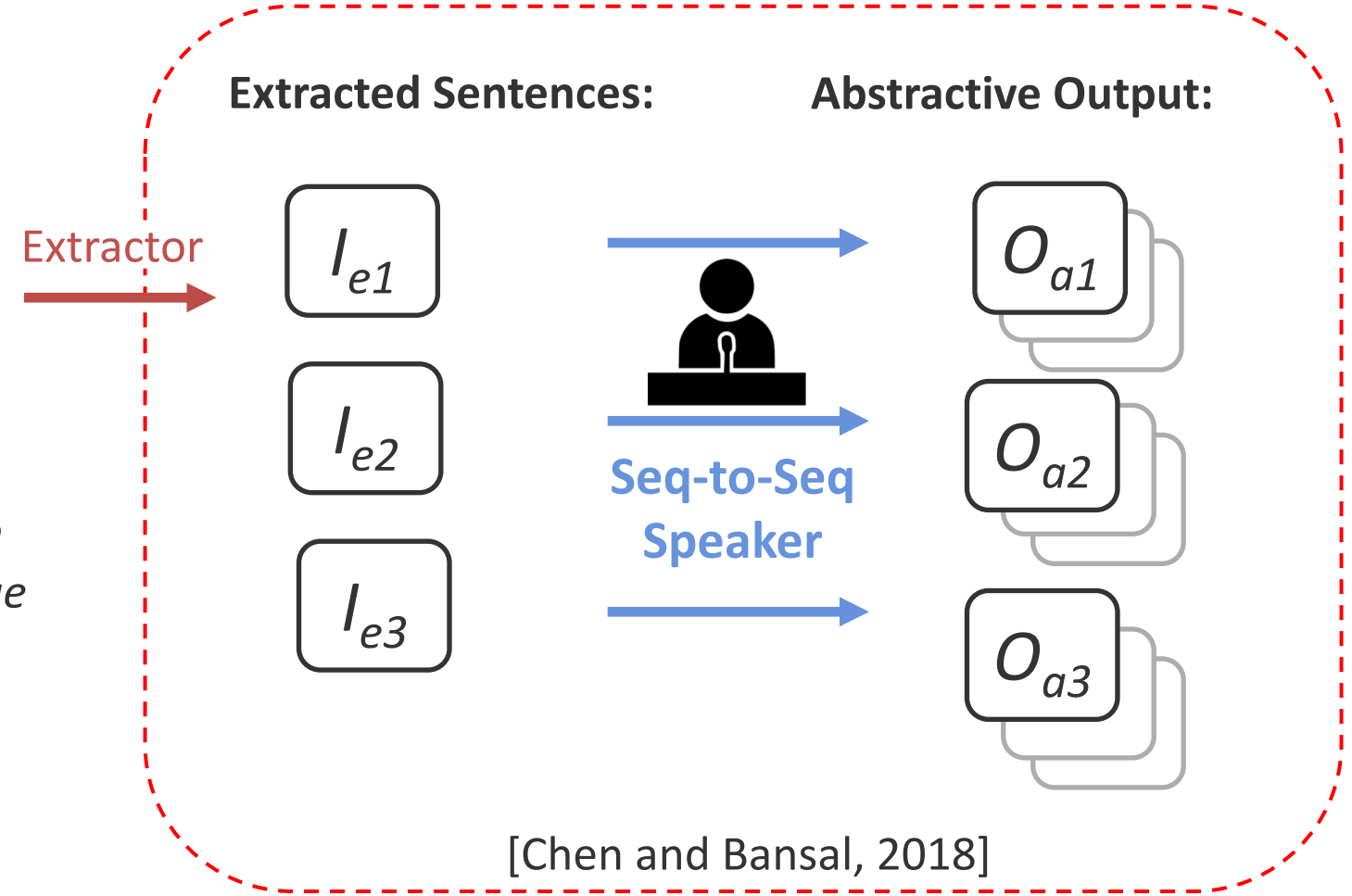
Generation from Meaning Representations



Abstractive Summarization

Long Document:

It is the primary reason all four English teams - Liverpool , Chelsea , Arsenal and Manchester City - were eliminated from the Champions League before the quarter-final draw.
…

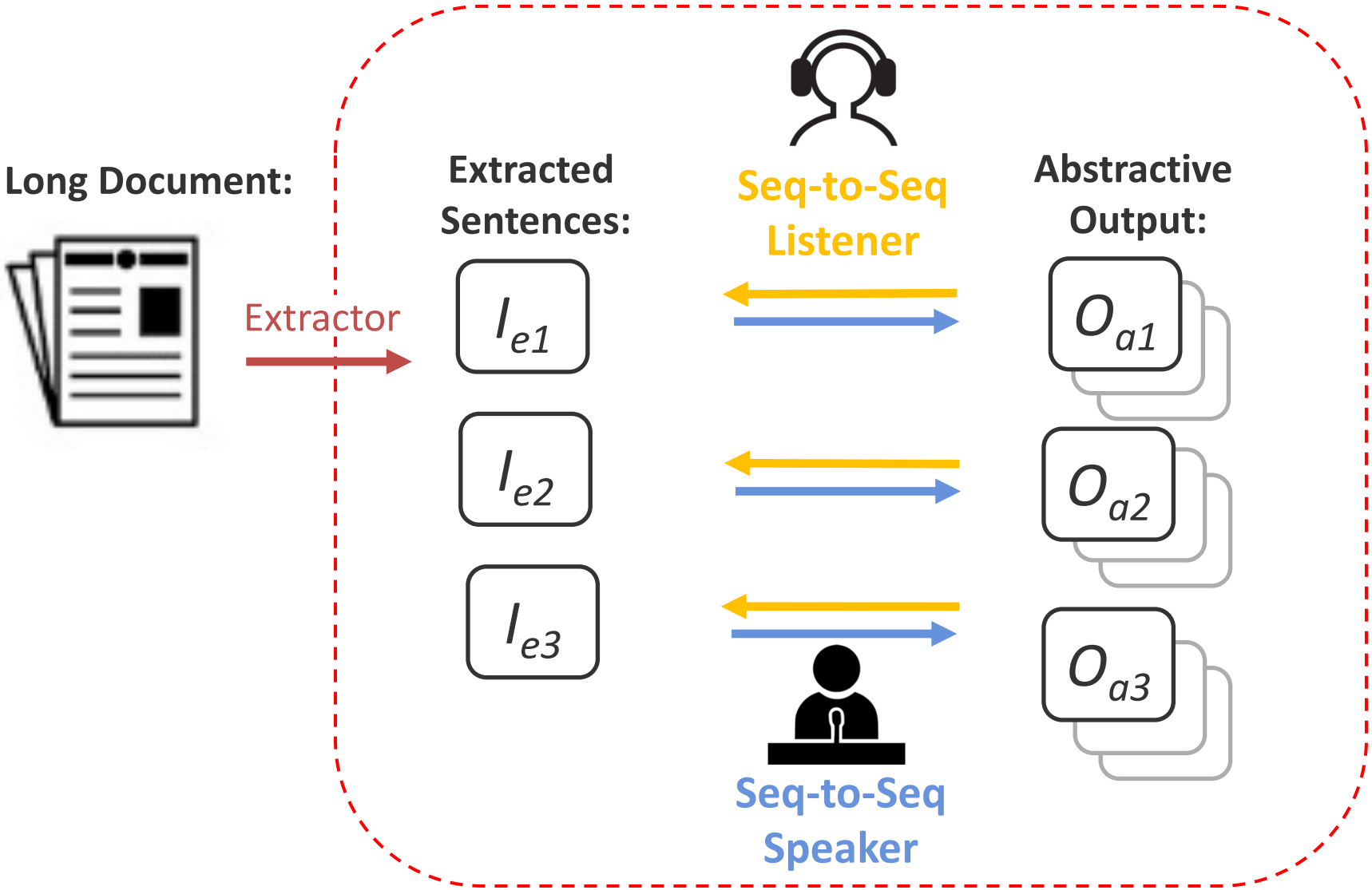


[Chen and Bansal, 2018]

Final Output:

1. Manchester City became the latest team to be eliminated from Europe;
2. City were dumped out of the Champions League last 16 by Barcelona.
3. …

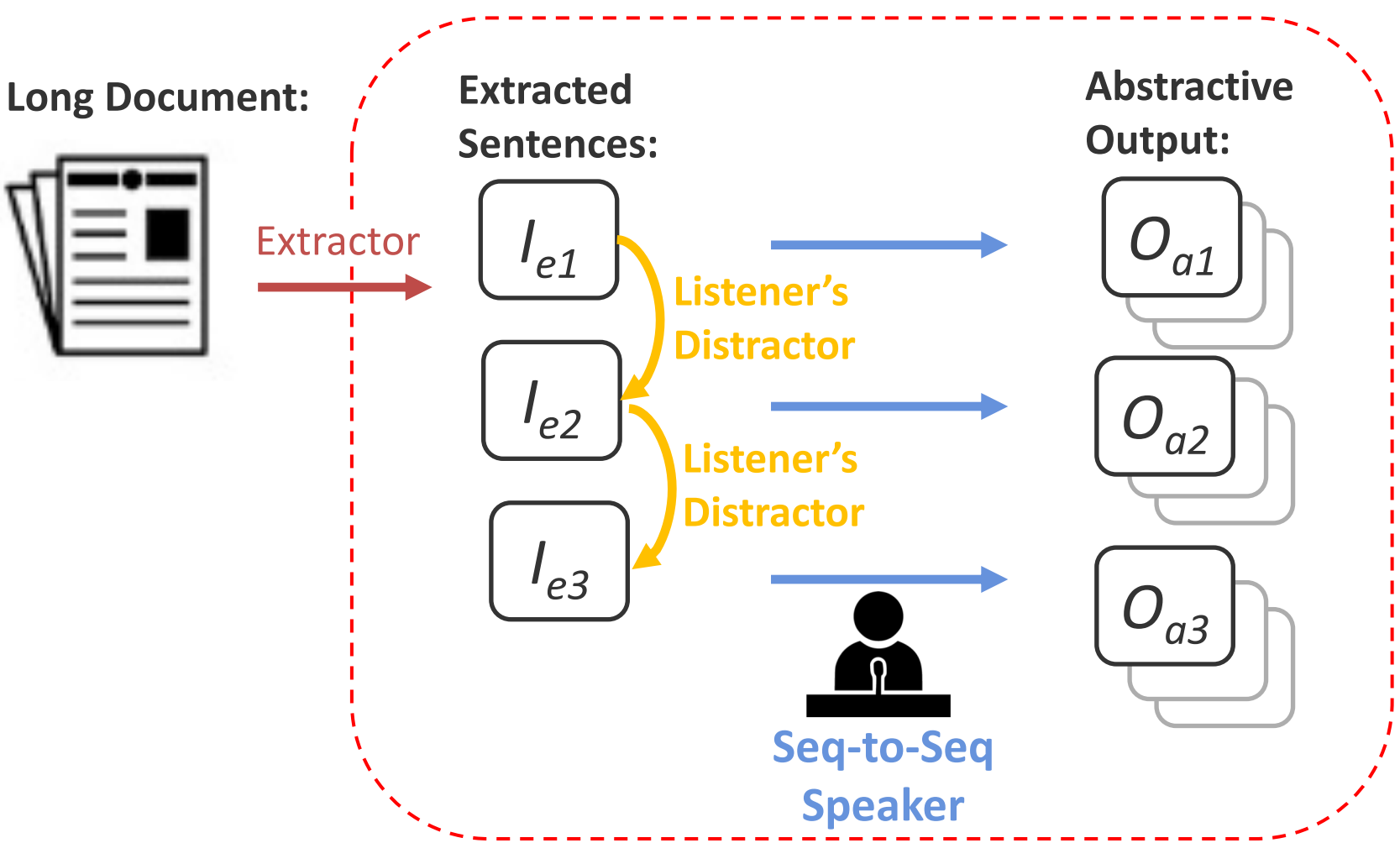
Abstractive Summarization



Reconstructor:

S^R (seq-to-seq model) maps abstractive outputs to extractive inputs.

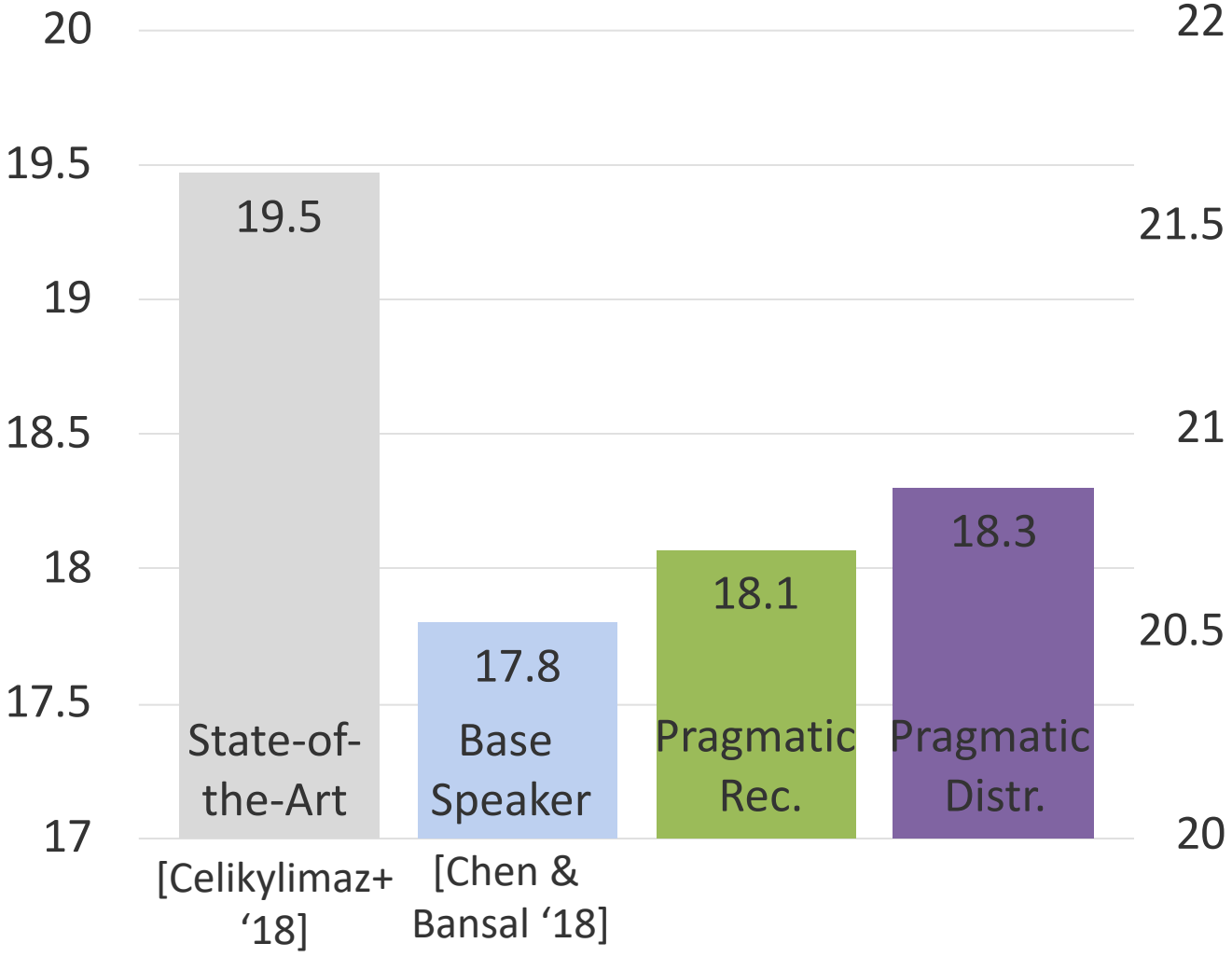
Abstractive Summarization

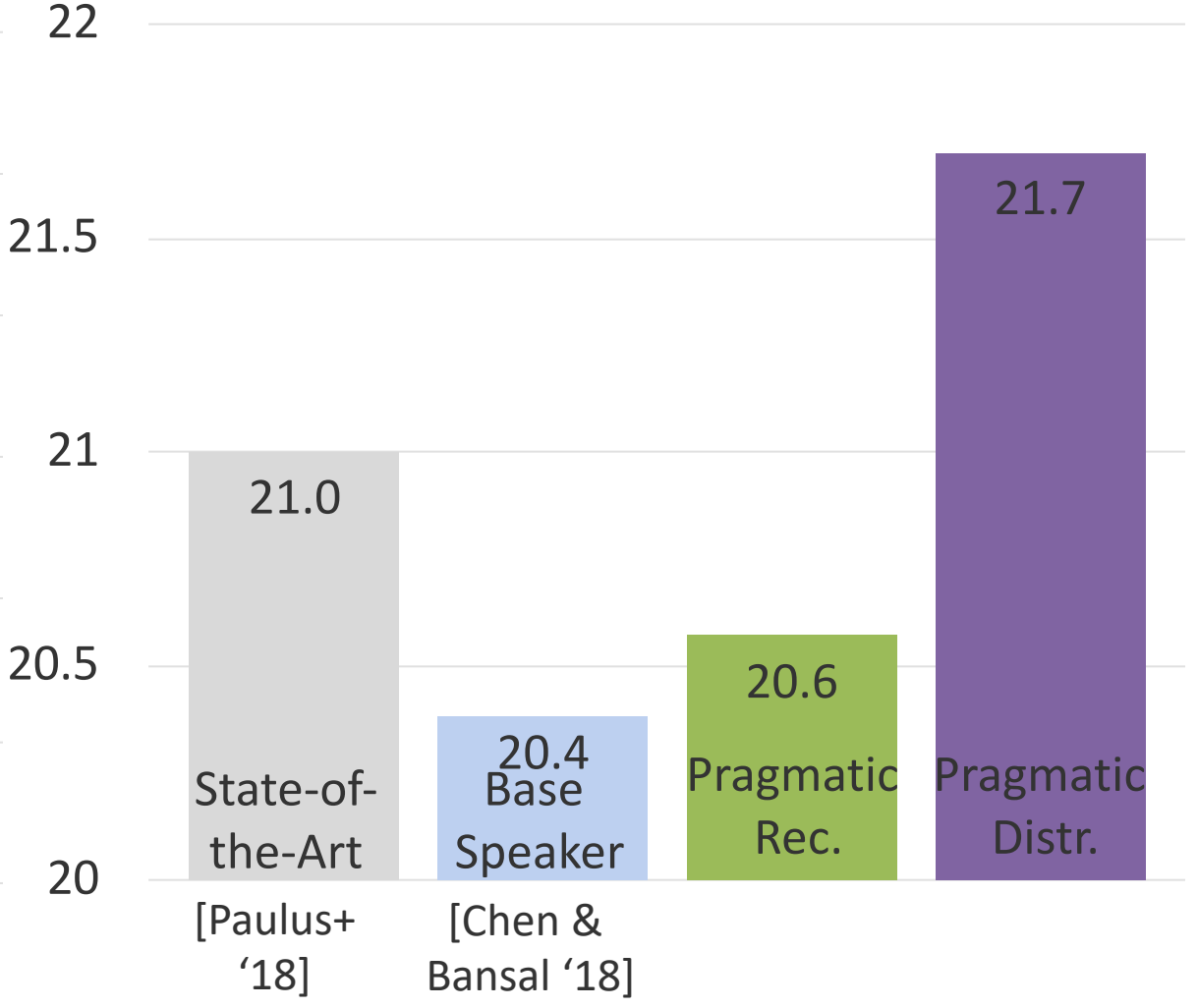


Distractor:

For a given extracted sentence, use the next extracted sentence as the distractor.

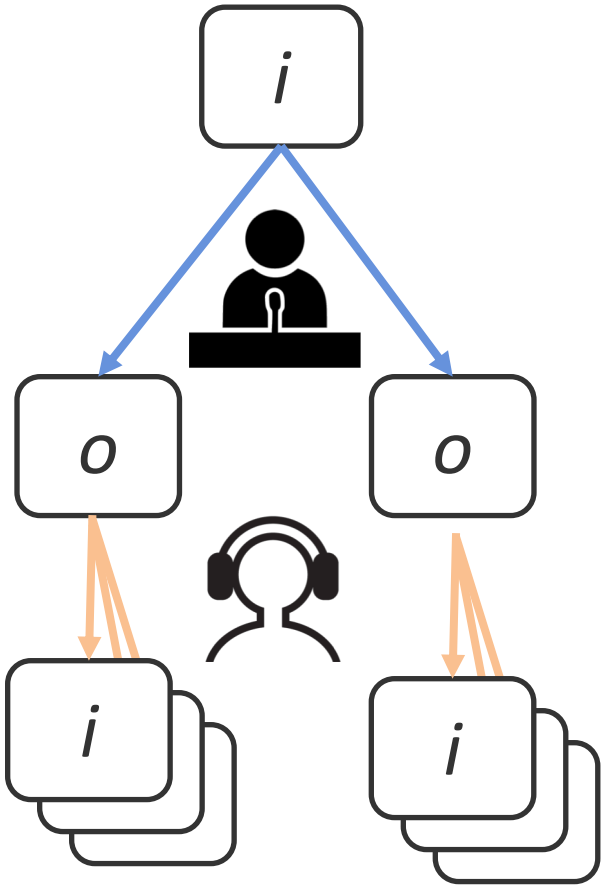
Abstractive Summarization





Conclusions

- Modeling generation as a speaker-listener game leads to more adequate and informative outputs
- Computational pragmatics produces improvements for general text generation tasks



Thanks!

Our code is publicly available at

`https://github.com/sIncerass/prag_generation`