At CoNLL-2021

NLPitch - ILLC - 26 October 2021

Analysing Human Strategies of Information Transmission as a Function of Discourse Context

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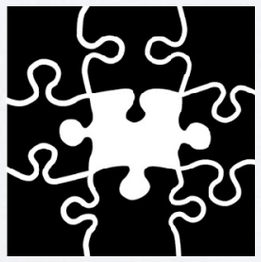
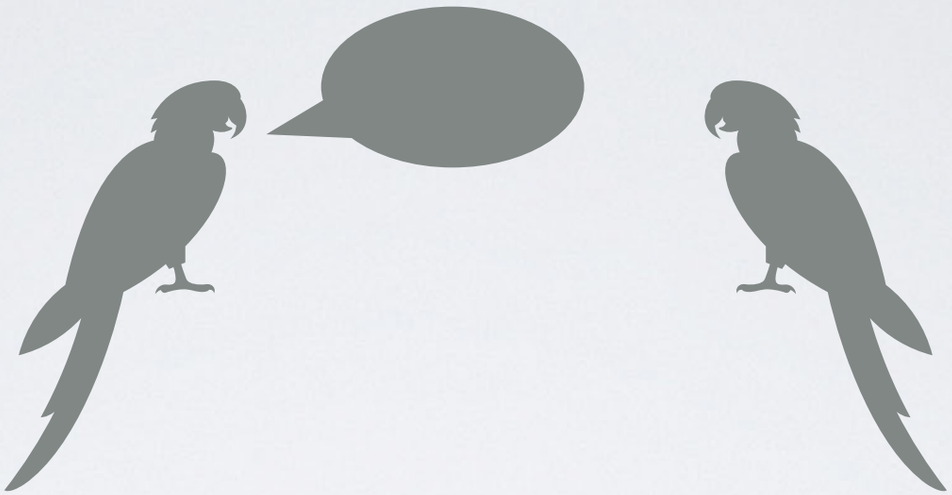


Collaborative effort in language production



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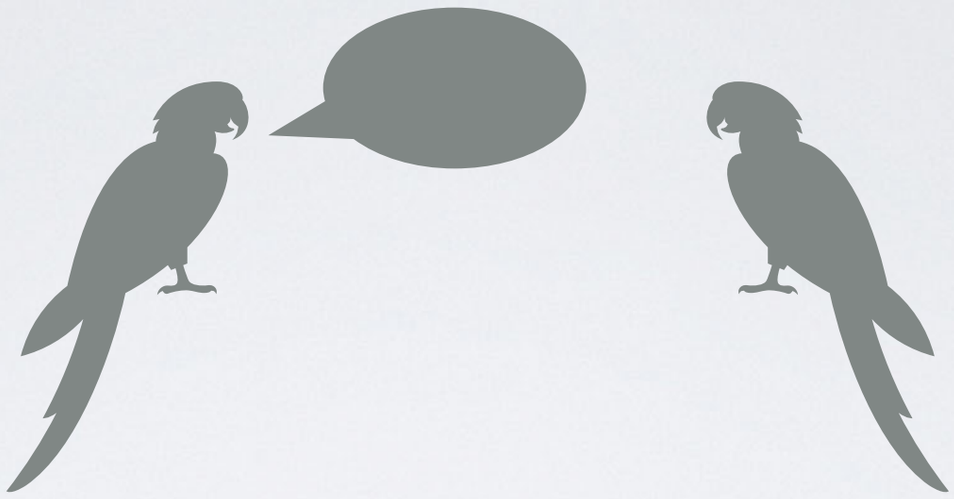
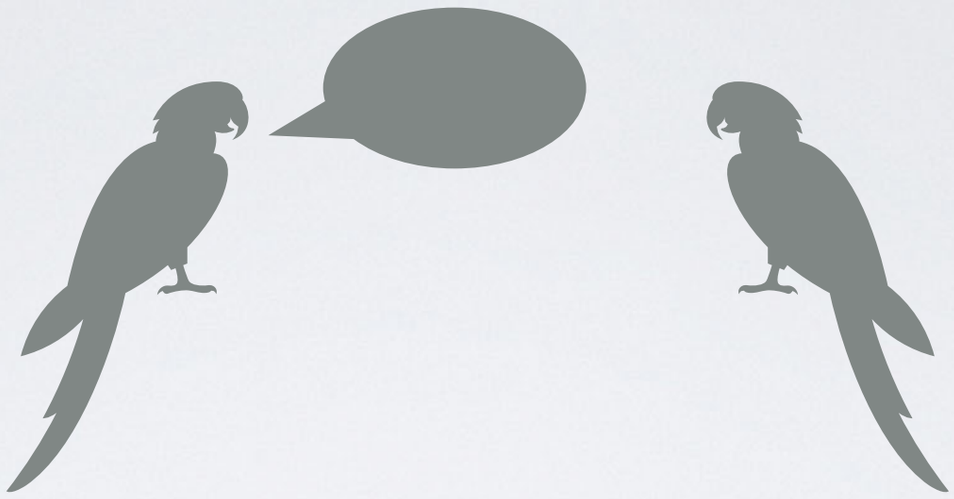


PROCESSING EFFORT

Collaborative effort in language production



PROCESSING EFFORT

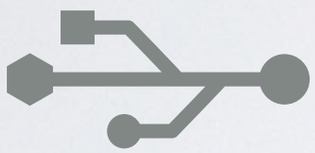
Amcore Financial Inc. said it agreed to acquire Central of Illinois Inc. in a stock swap.

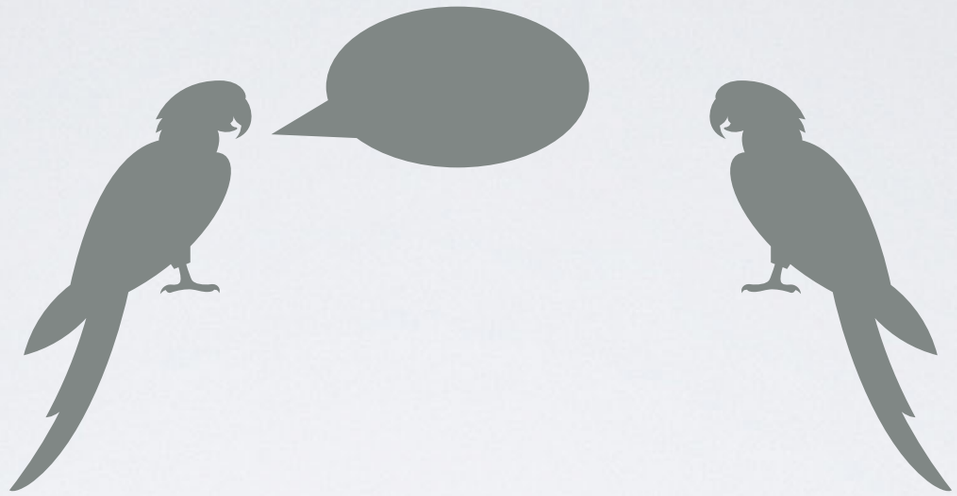
Shareholders of Central, a bank holding company based in Sterling, will receive Amcore stock equal to 10 times Central's 1989 earnings, Amcore said.

For the first nine months of 1989, Central of Illinois Inc., a bank holding company based in Sterling, earned $2 million.

Collaborative effort in language production

PRODUCTION
EFFORT





Collaborative effort in language production

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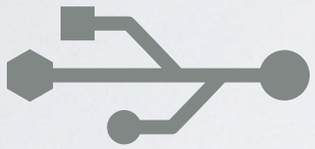

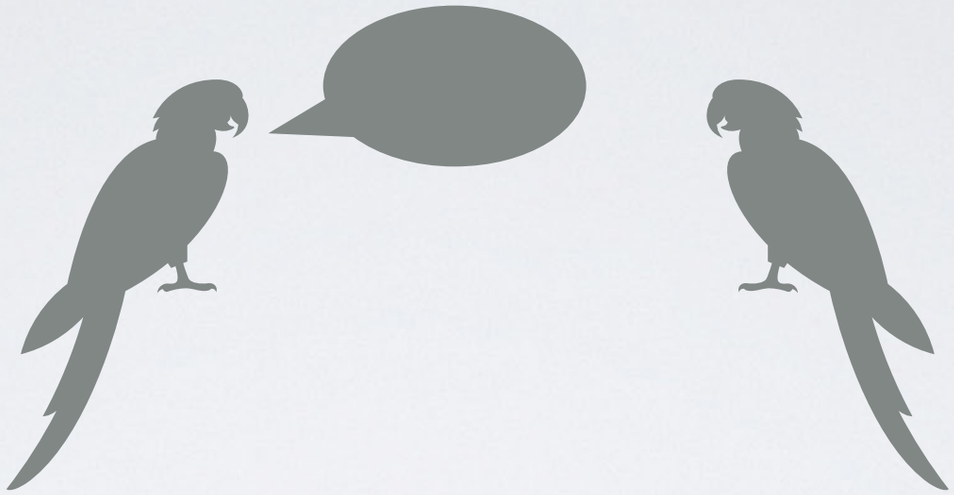

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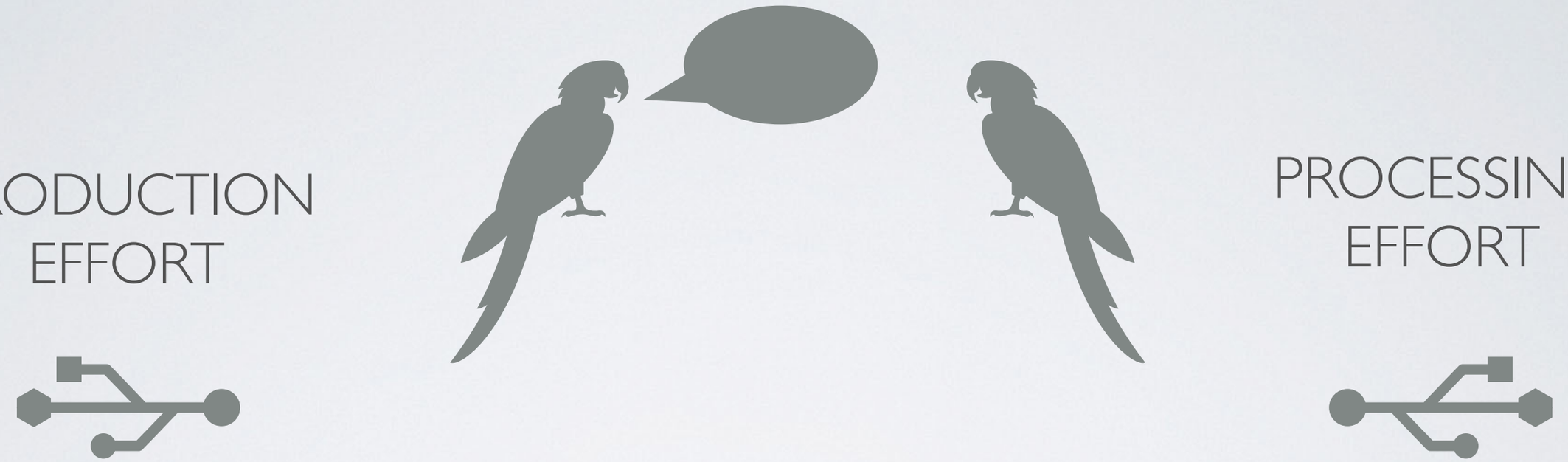

PRODUCTION EFFORT

PROCESSING EFFORT

Information Theory
(Shannon, 1948)

Information-theoretic measures

Information-theoretic measures

$H(S)$ Shannon information content

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Information-theoretic measures

$H(S)$ Out-of-context information content

$I(S;C)$ Mutual information

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$H(S \mid C) \equiv H(S) - I(S;C)$ In-context information content

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Entropy Rate Constancy

$H(S)$ Out-of-context information content

$I(S;C)$ Context informativeness

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(Genzel & Charniak, 2002)

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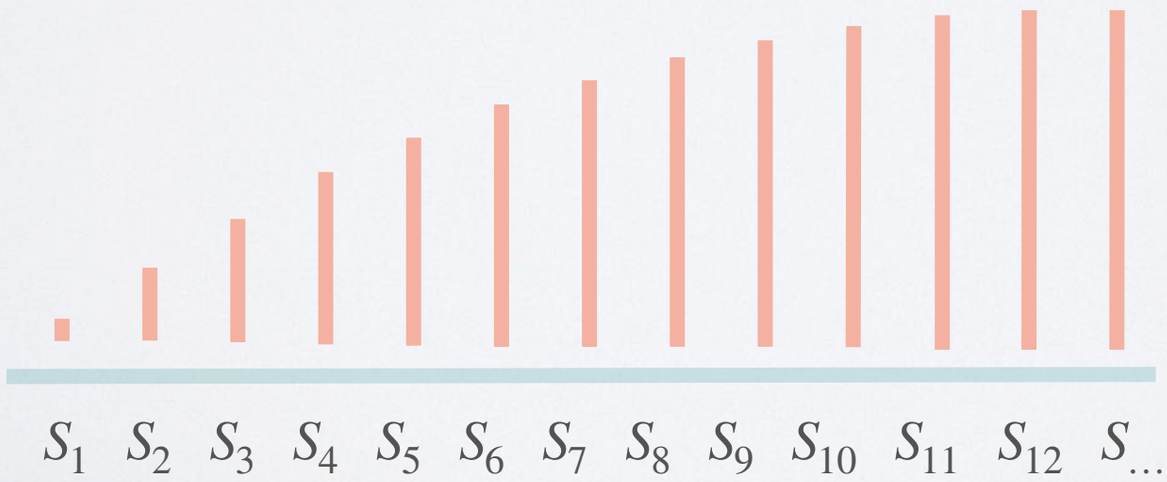

$I(S;C)$

$H(S \mid C)$

(Genzel & Charniak, 2002)

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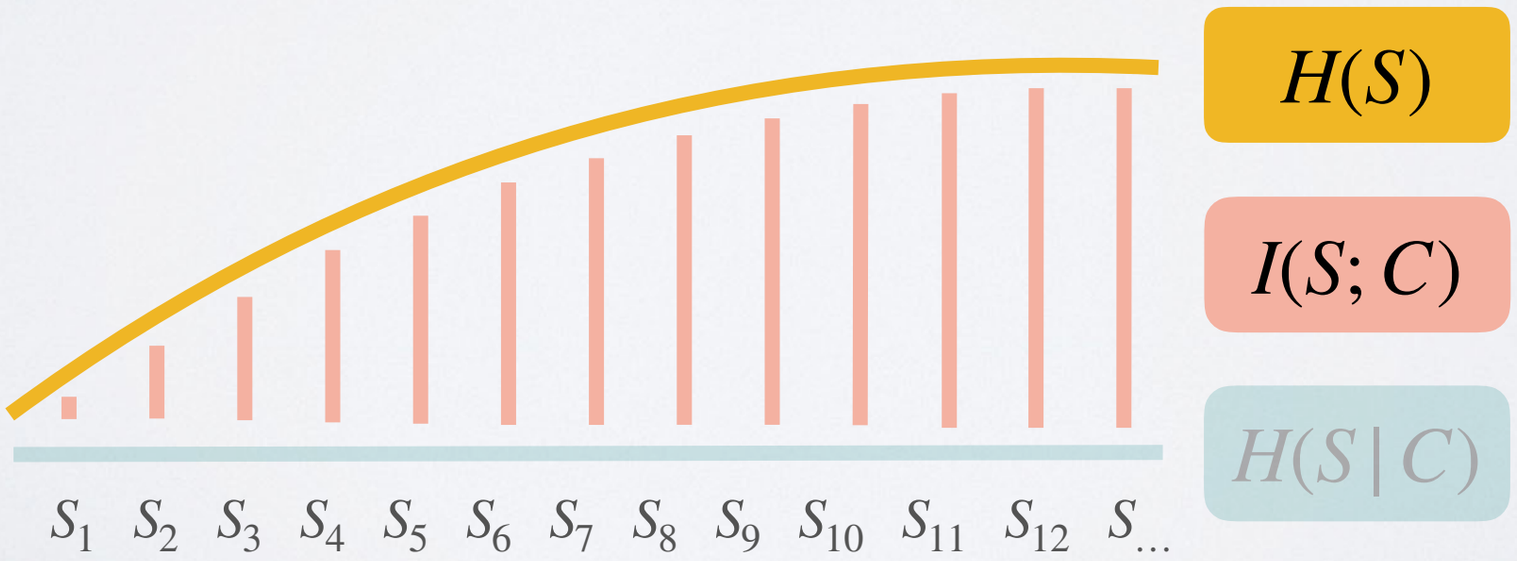

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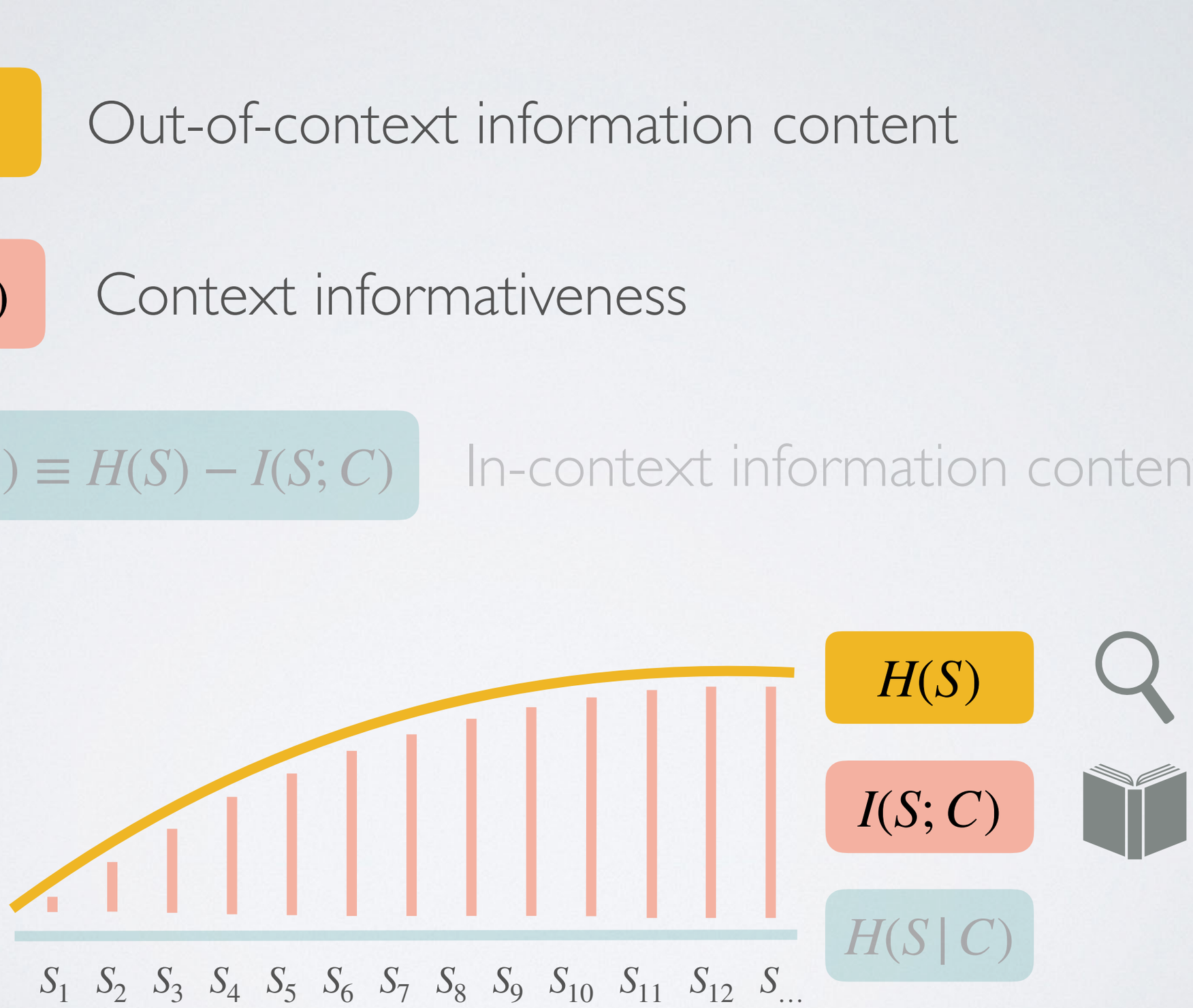

(Genzel & Charniak, 2002)

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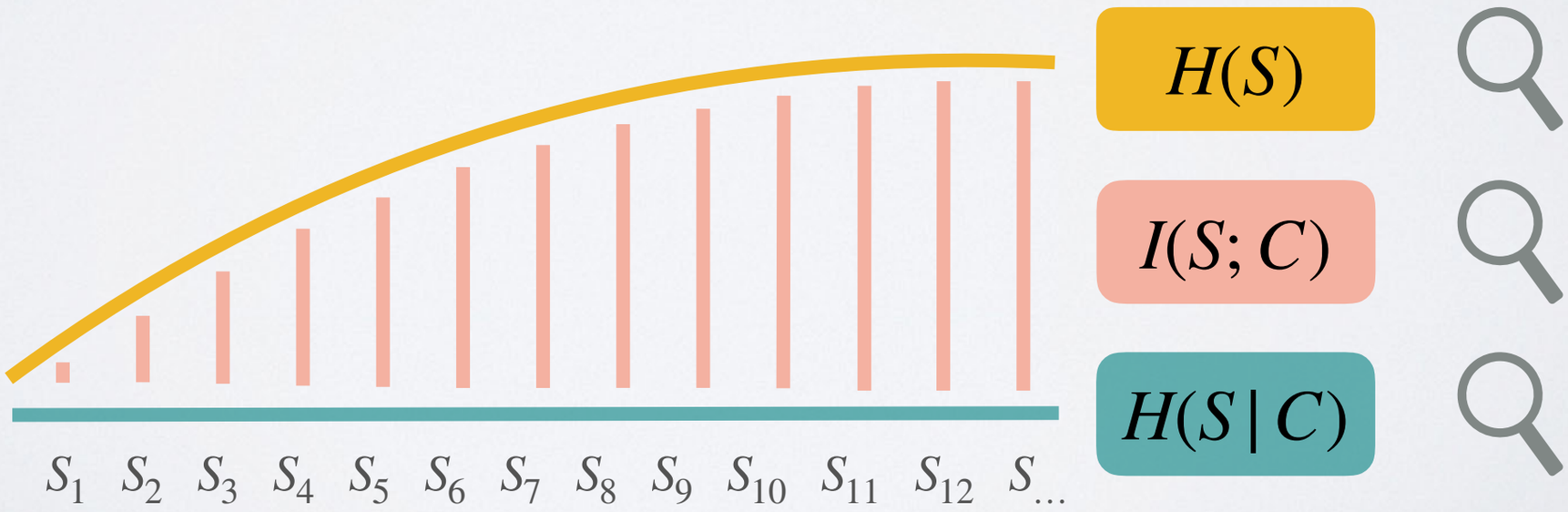

The current study

Estimates of information content

$$H(S) = -\log_2(S) = -\frac{1}{|S|}\sum_{w_i \in S} \log_2 P(w_i \mid w_1, \ldots, w_{i-1})$$

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$$I(S; C) \equiv H(S) - H(S \mid C)$$

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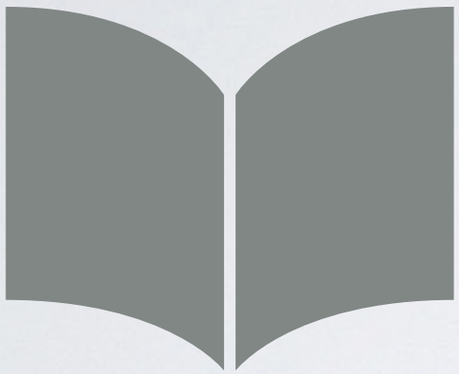
$$I(S; C) \equiv H(S) - H(S \mid C)$$

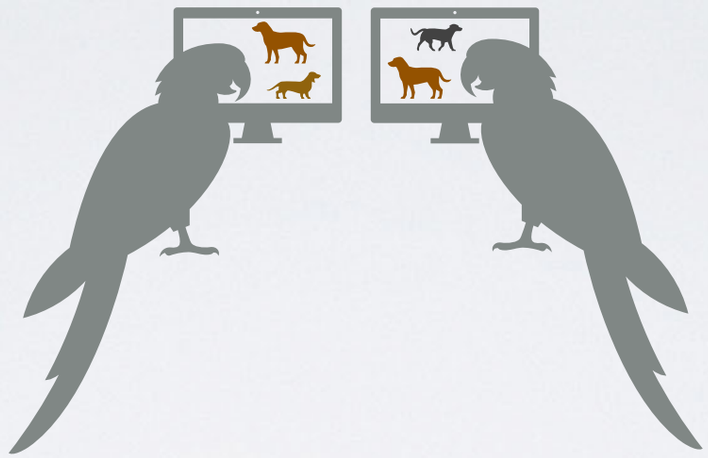
$P(w_i \mid \ldots)$ estimates obtained with GPT-2
fine-tuned on 70% of each target corpus

(30% held-out for analysis)

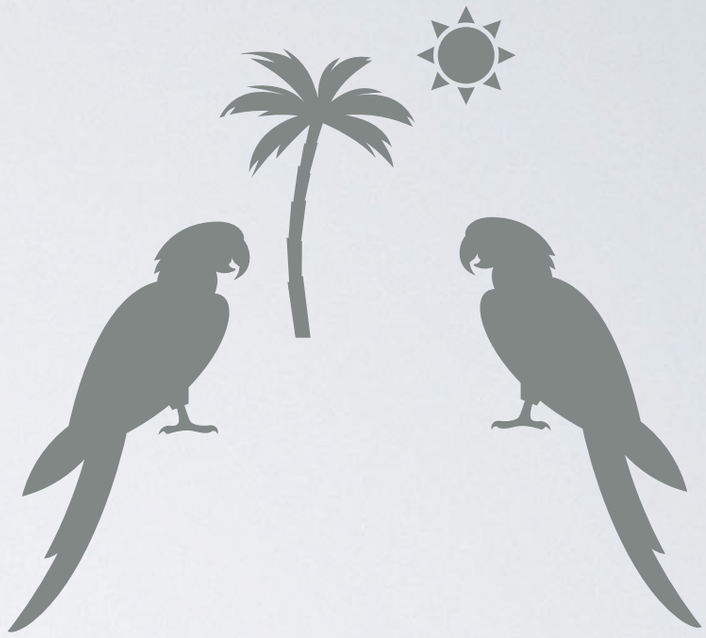
Experimental data



Penn Treebank
newspaper
articles
(Mitchell et al. 1999)

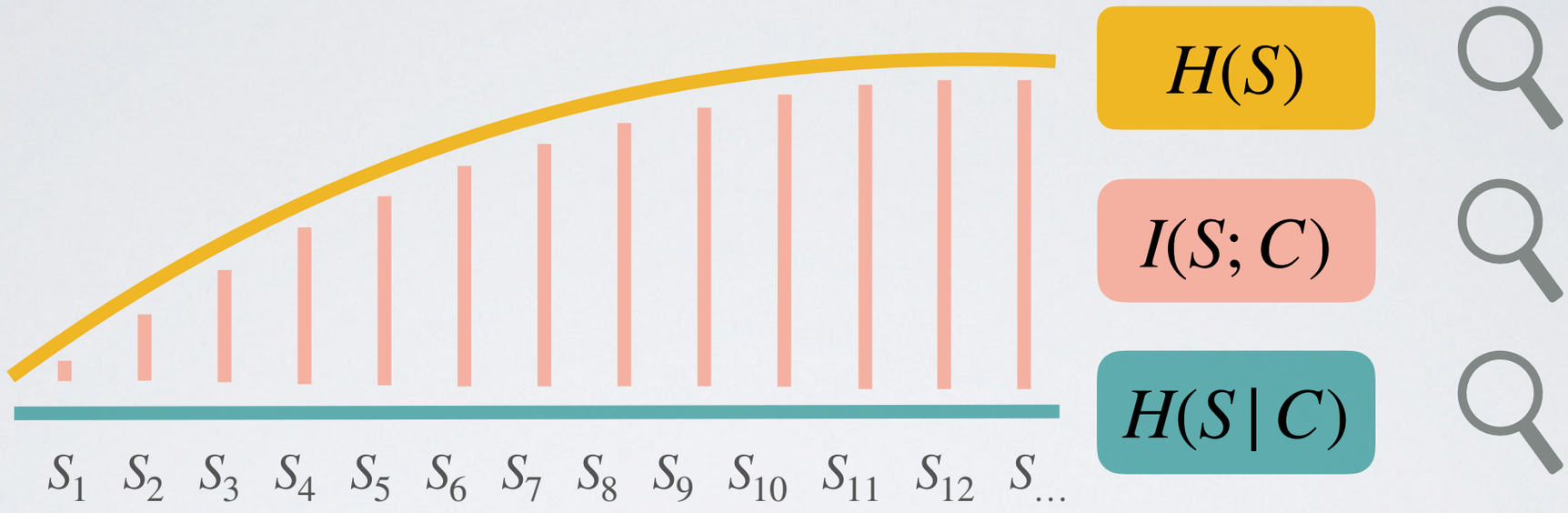


PhotoBook
task-oriented
written dialogues
(Haber et al., 2019)



Spoken BNC
open domain
dialogues
(Love et al., 2017)

Experiment 1



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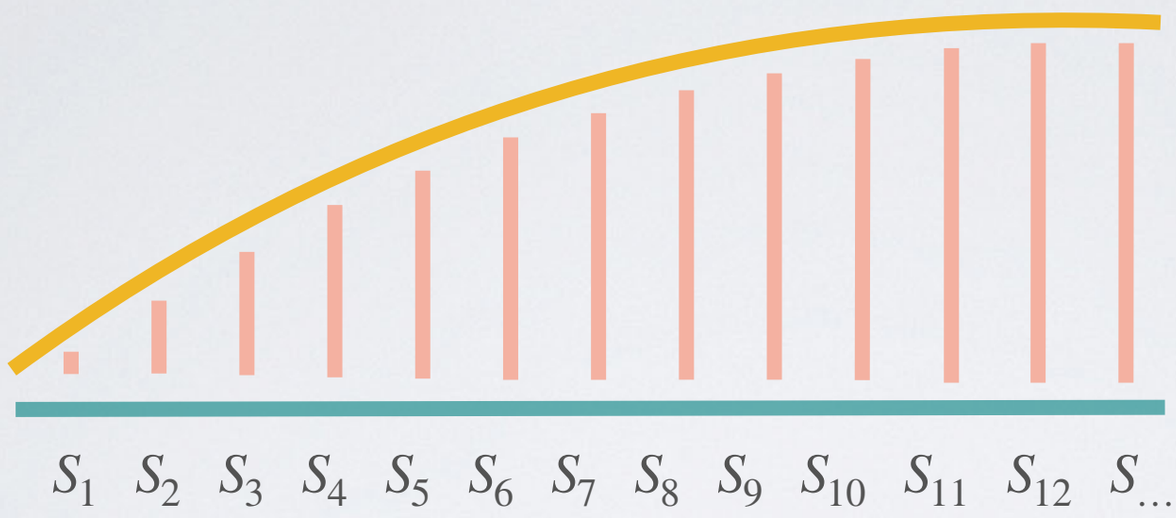


$H(S)$

$I(S;C)$

$H(S \mid C)$

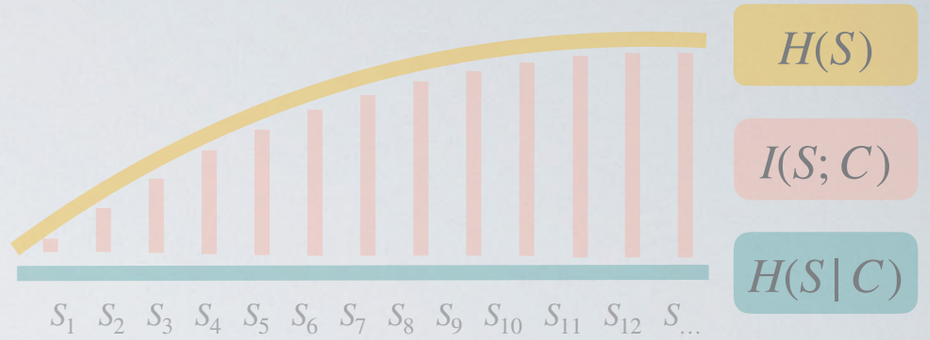
$H(S)$ ~ fixed effects

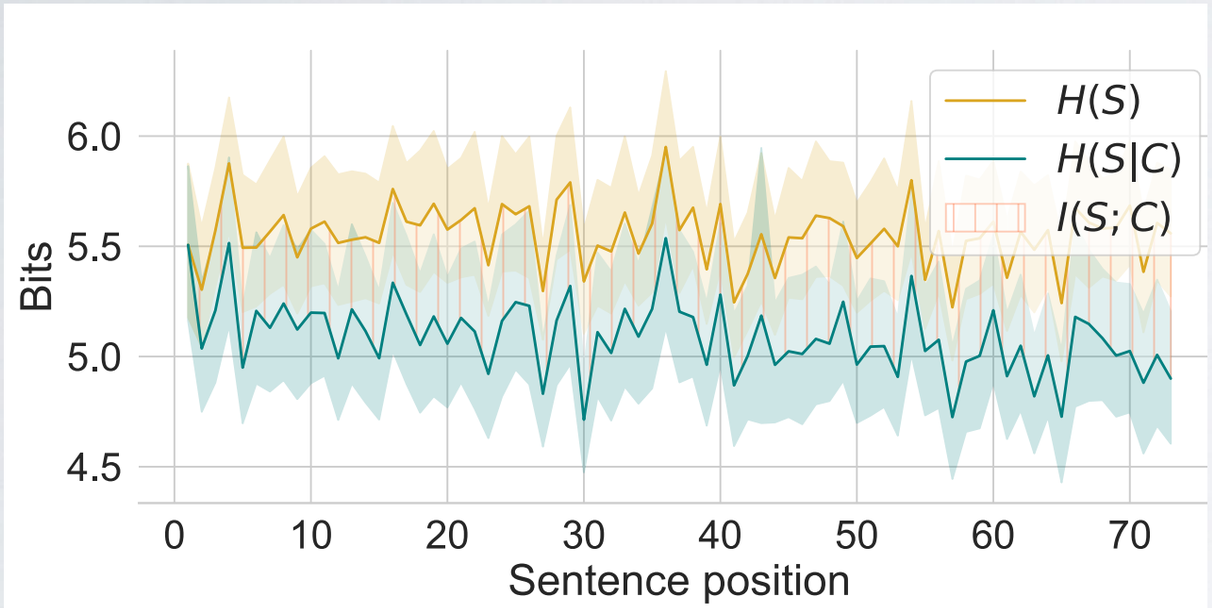
$I(S;C)$ ~ 1 + log sentence position + log sentence length

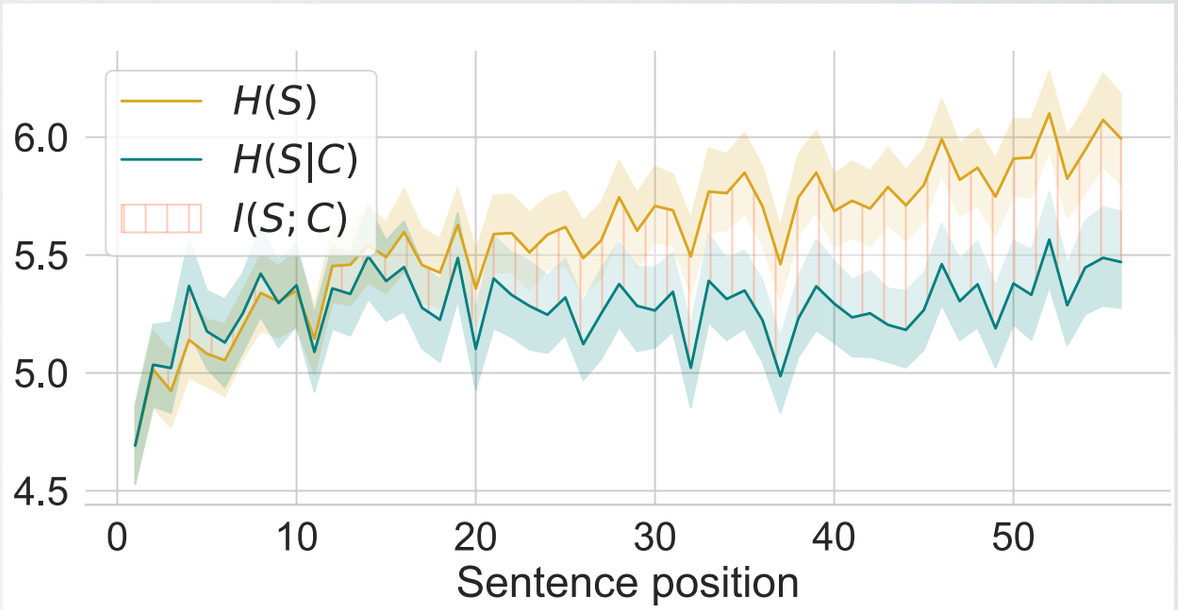
$H(S \mid C)$ ~ + (1 + log sentence position + log sentence length | doc_id)

random intercept and slope
grouped by text / dialogue

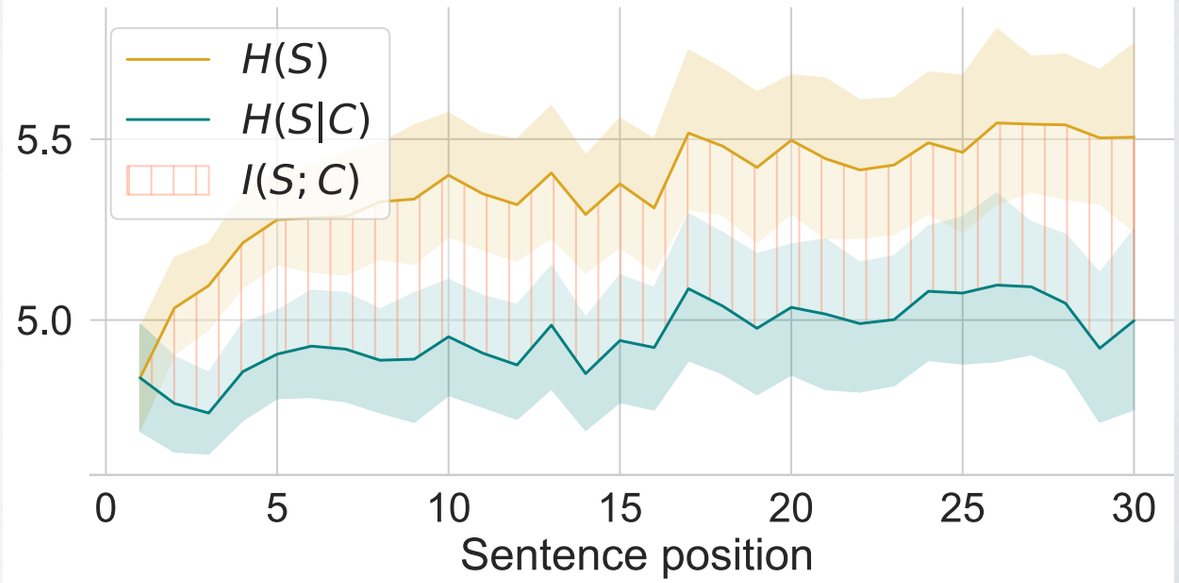
Experiment 1







Effect of sentence position



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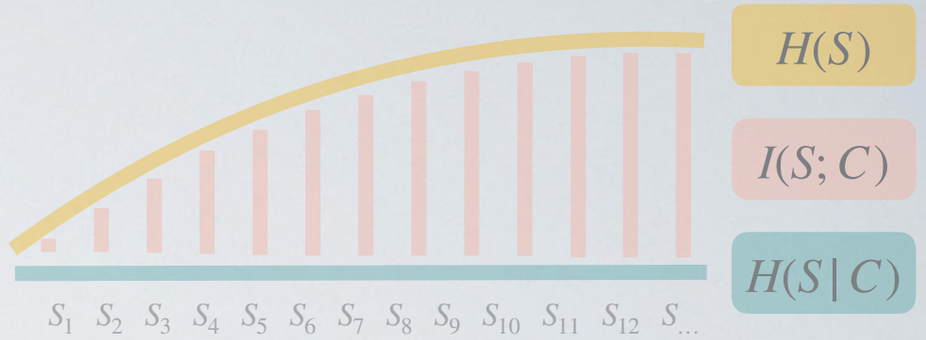

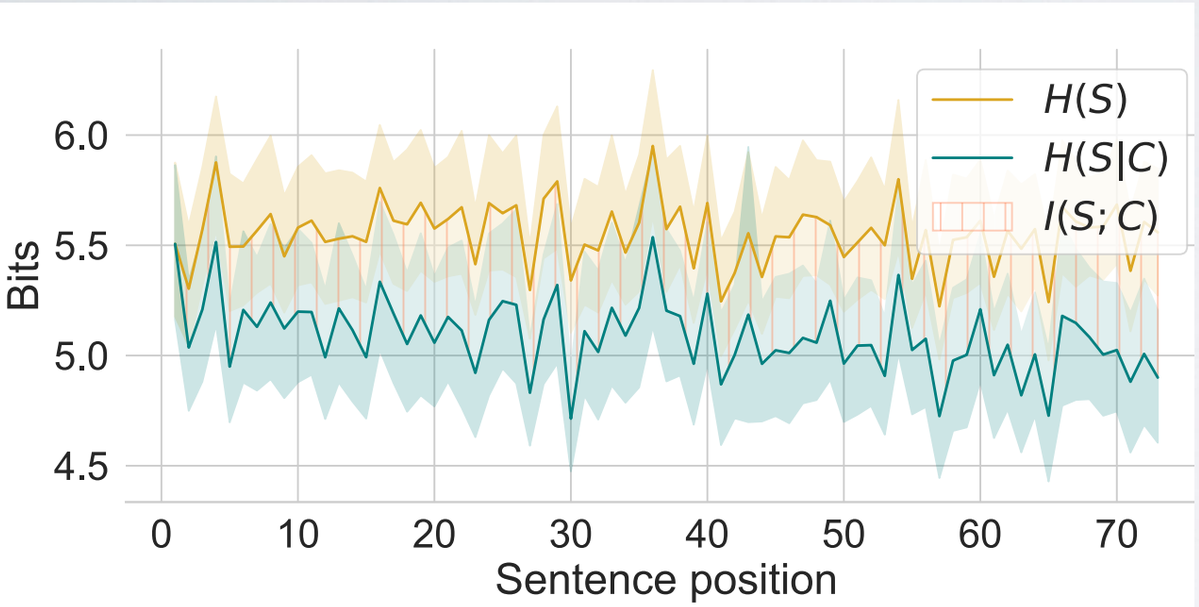

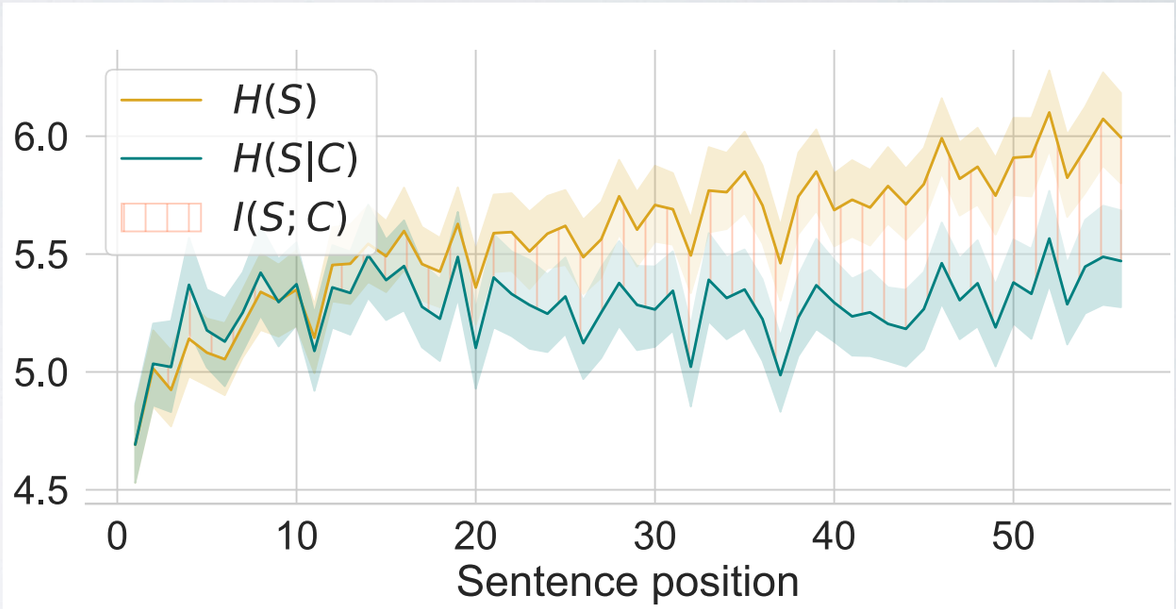

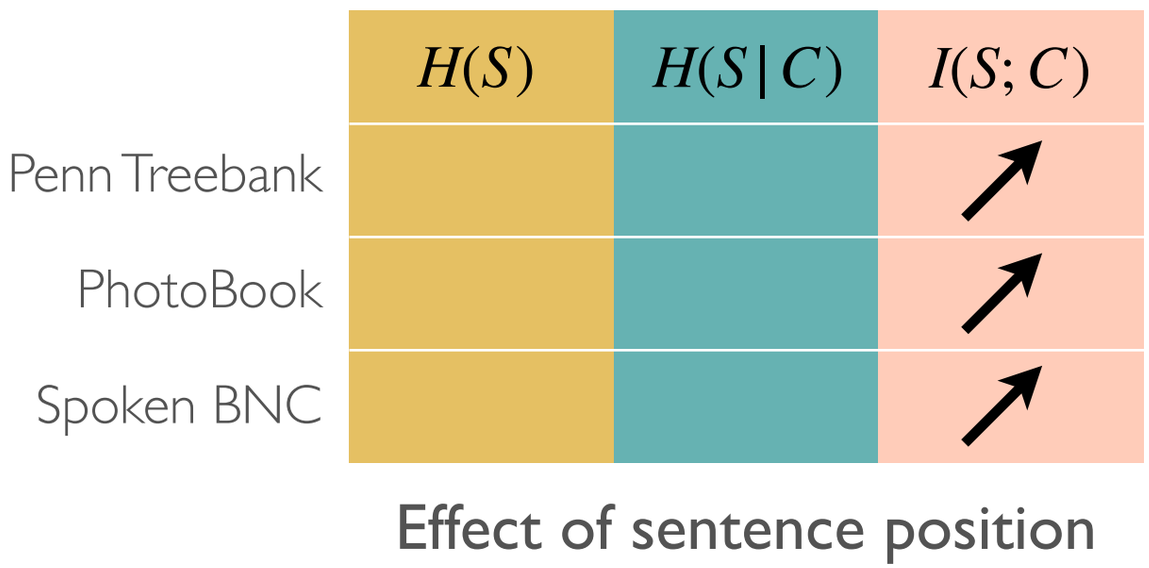

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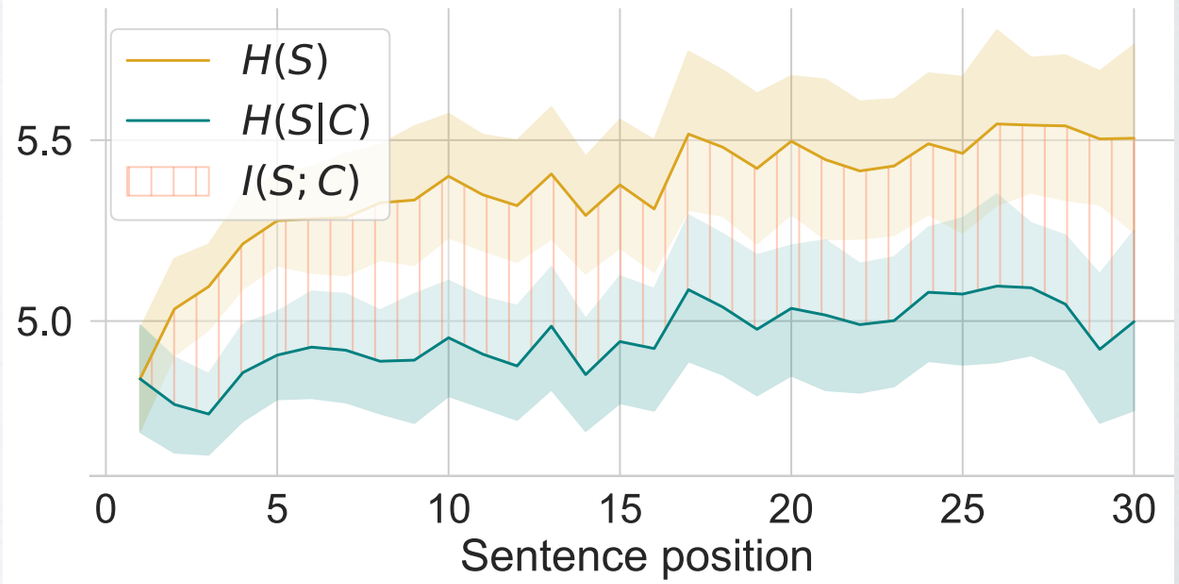

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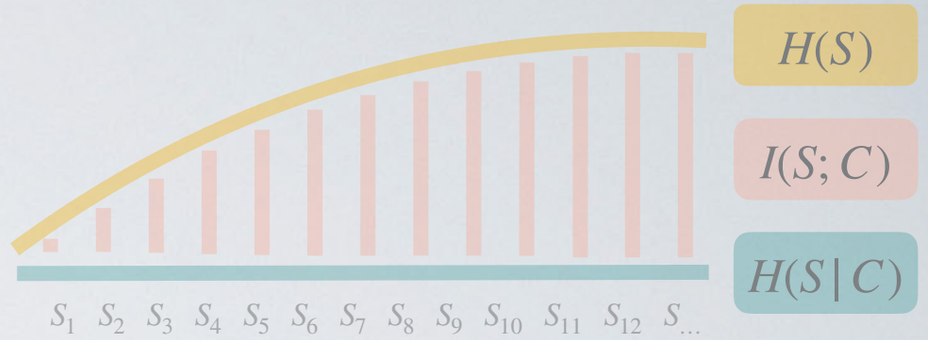

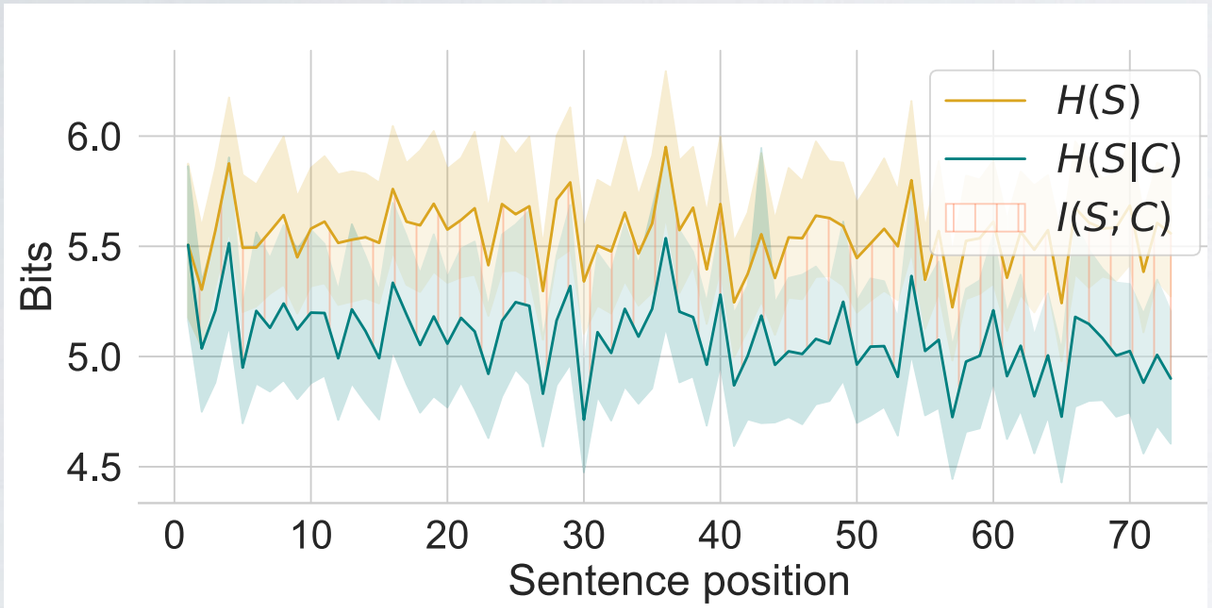

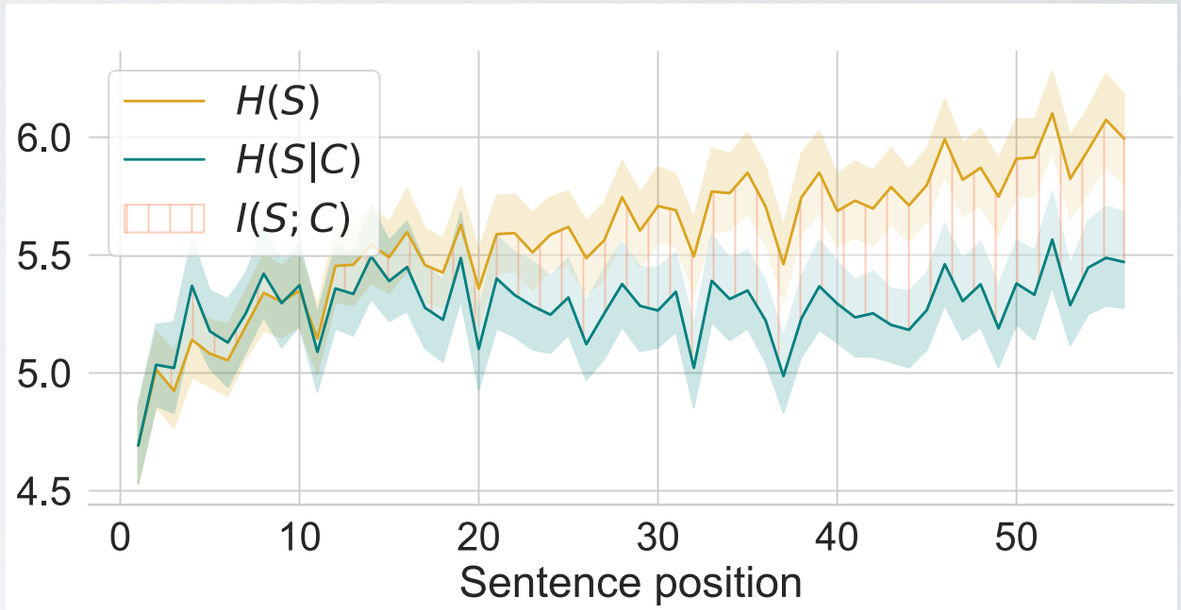

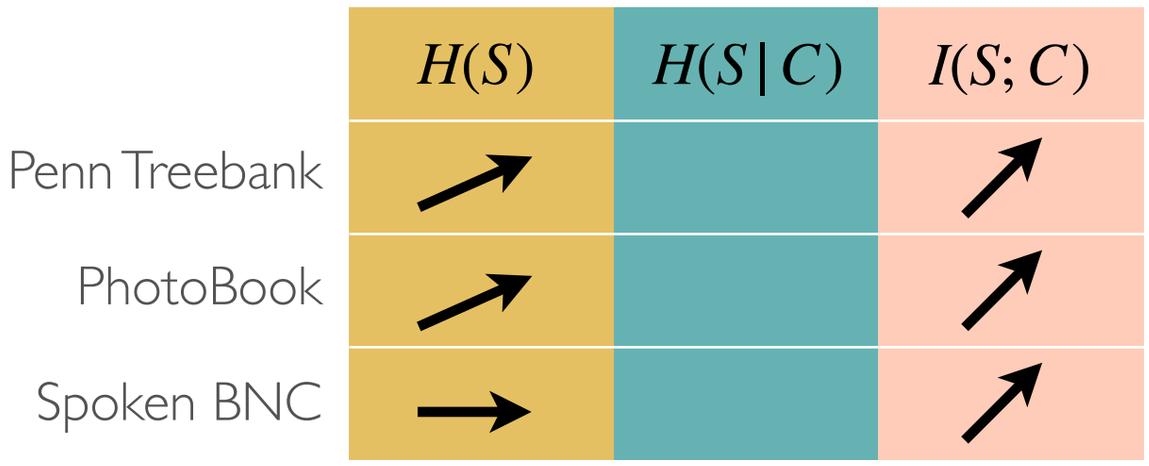

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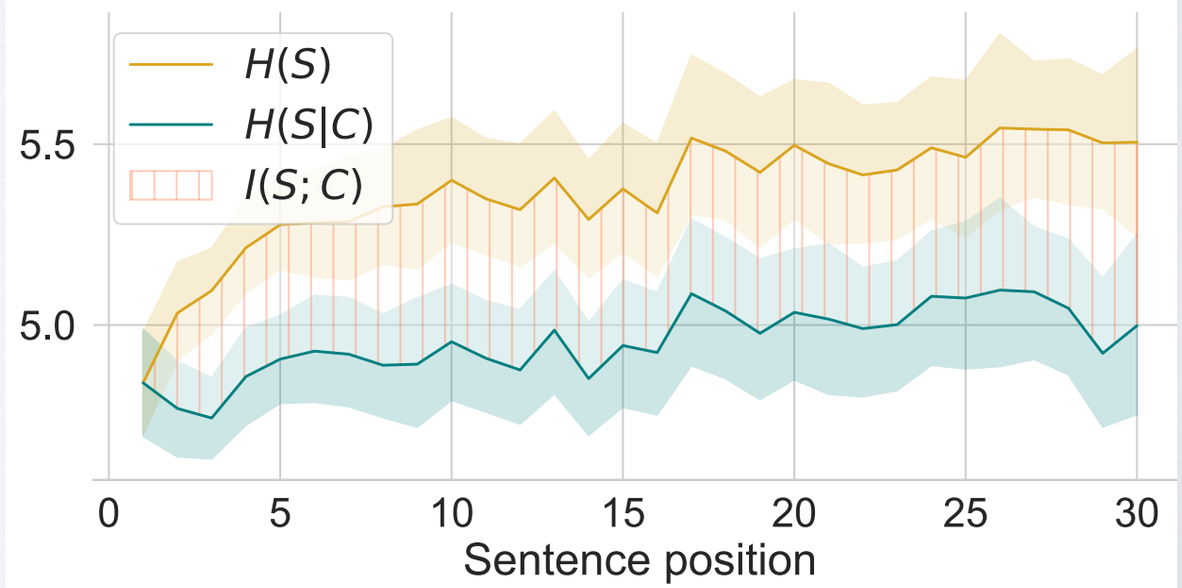

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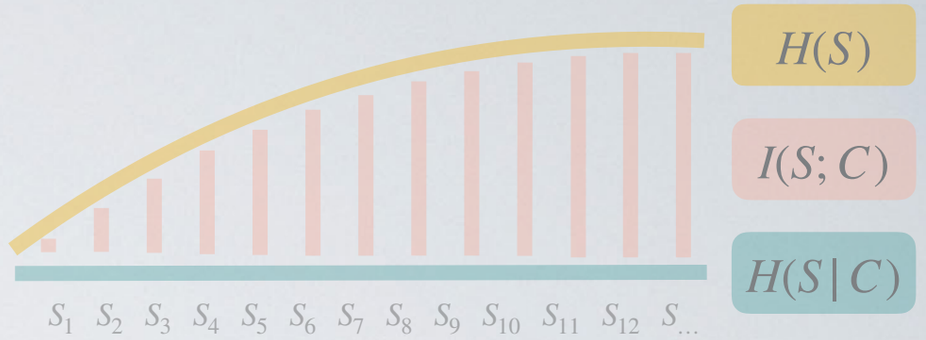

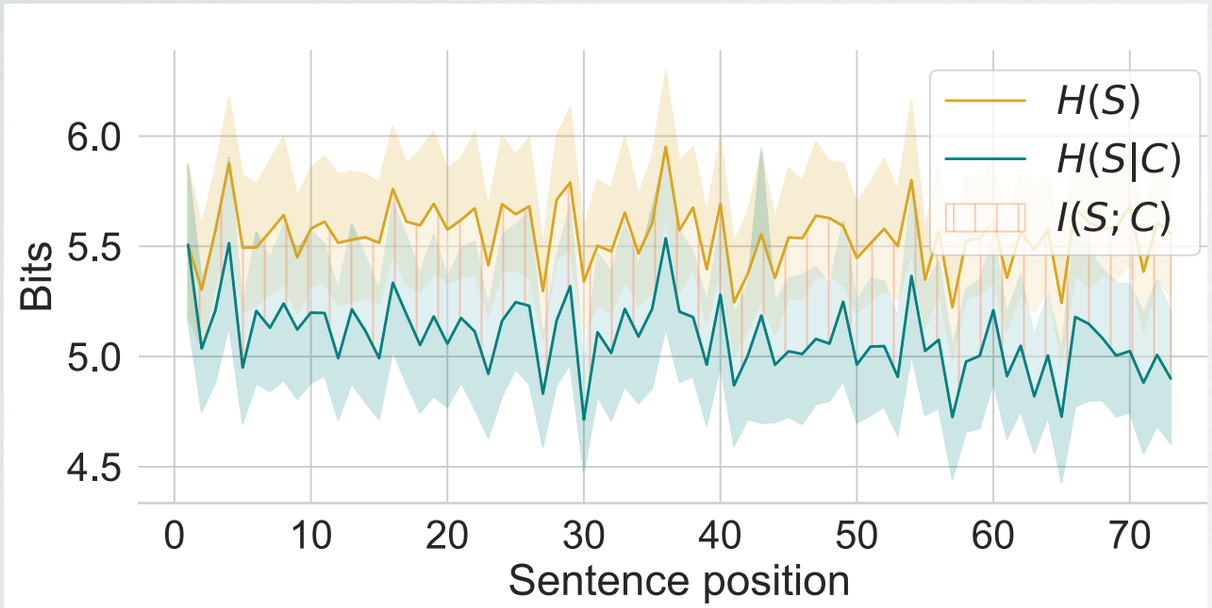

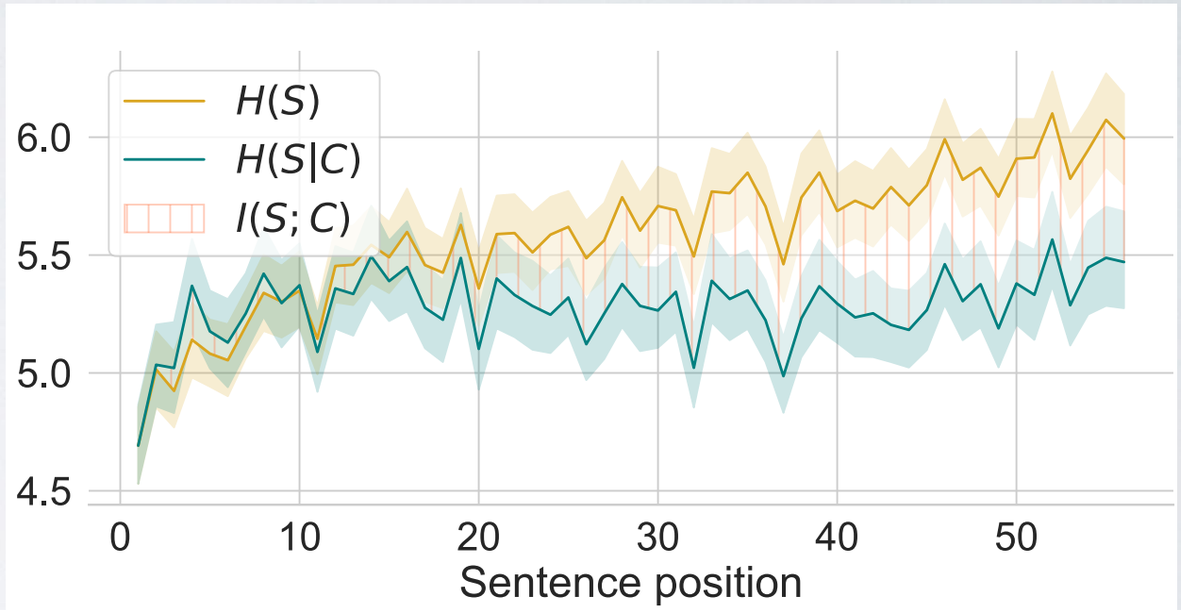

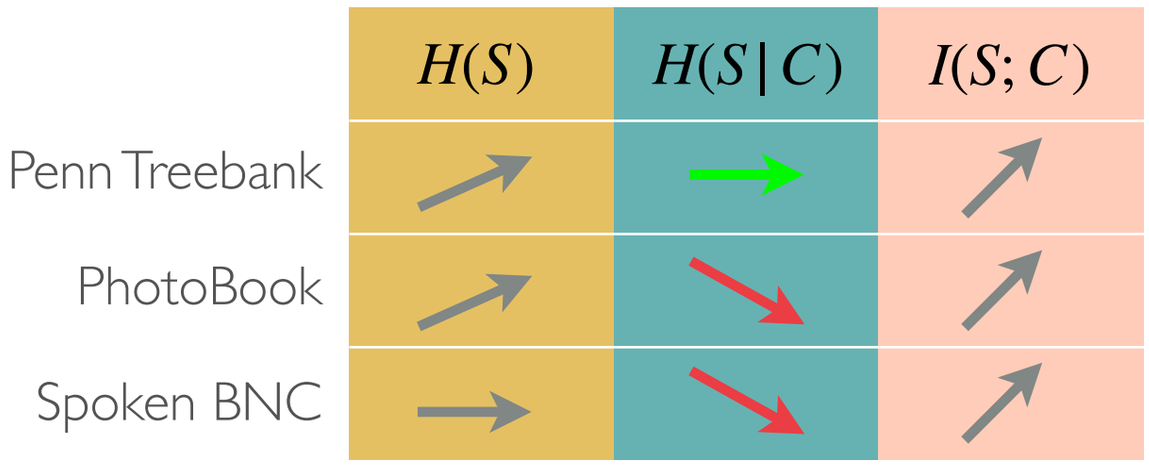

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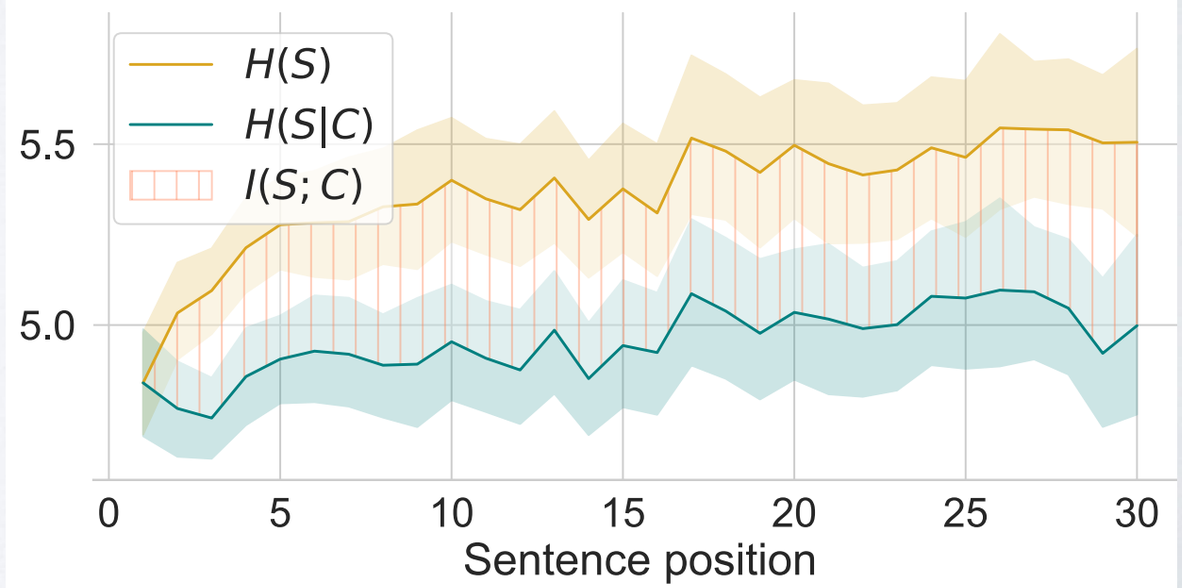

$H(S \mid C)$

Experiment 2

Entropy Rate Constancy

(Genzel & Charniak, 2002)

S_1 S_2 S_3 S_4 S_5 S_6 S_7 S_8 $S_{...}$

$H(S \mid C)$

Experiment 2

Entropy Rate Constancy

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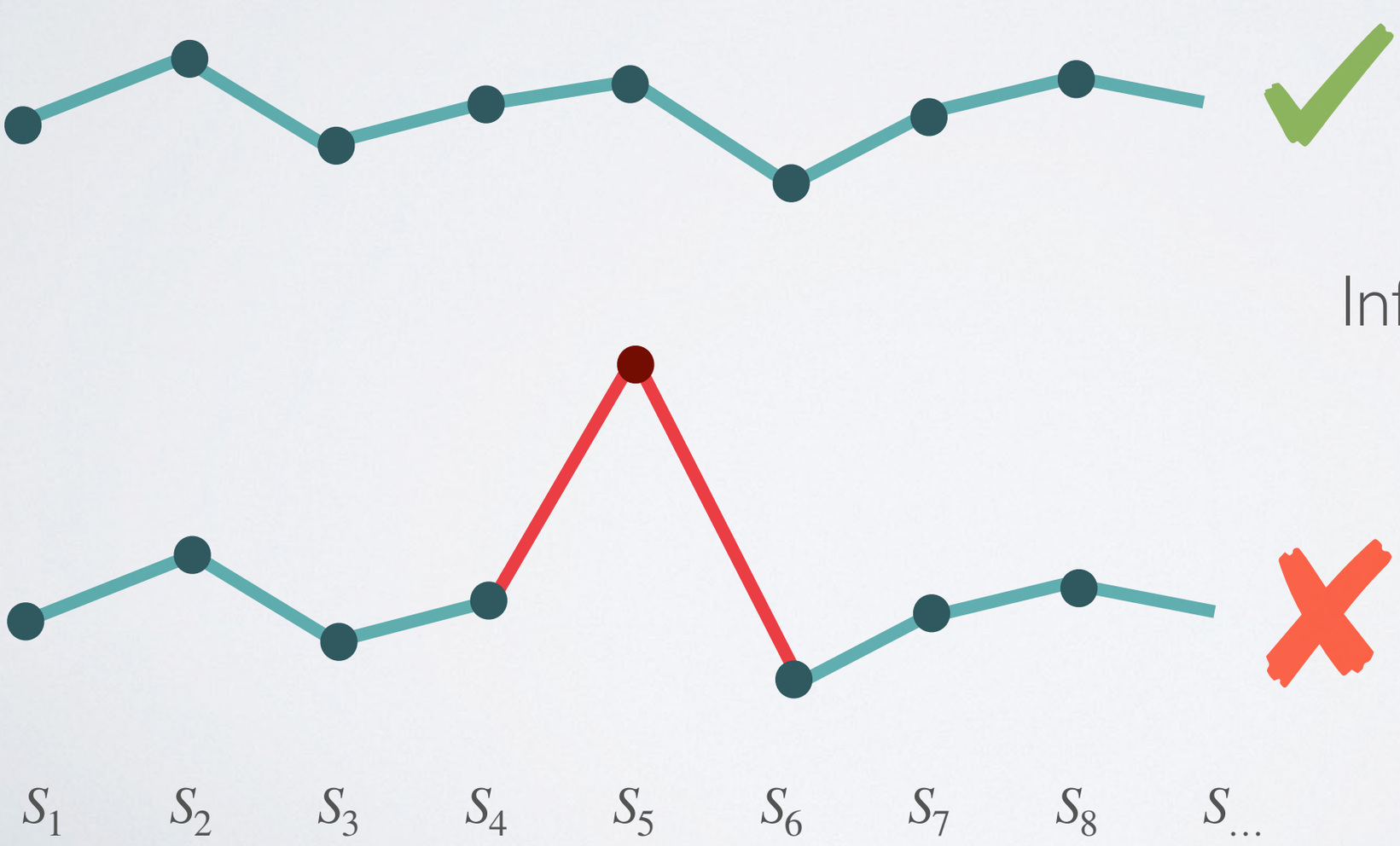

Uniform
Information Density

(Aylett & Turk, 2004;
Jaeger & Levy, 2007;
Levy, 2010)

S_1 S_2 S_3 S_4 S_5 S_6 S_7 S_8 $S_{...}$

Experiment 2

Criteria of uniformity (Collins, 2014)

Global centrality

$$-\frac{1}{N}\sum_{i=1}^{N}\left(H\left(S_i \mid C_i\right)-\mu\right)^2$$

Local predictability

$$-\frac{1}{N}\sum_{i=2}^{N}\left(H\left(S_i \mid C_i\right)-H\left(S_{i-1} \mid C_{i-1}\right)\right)^2$$

N number of sentences in the text / dialogue

μ average information content in the text / dialogue

Experiment 2

Global centrality

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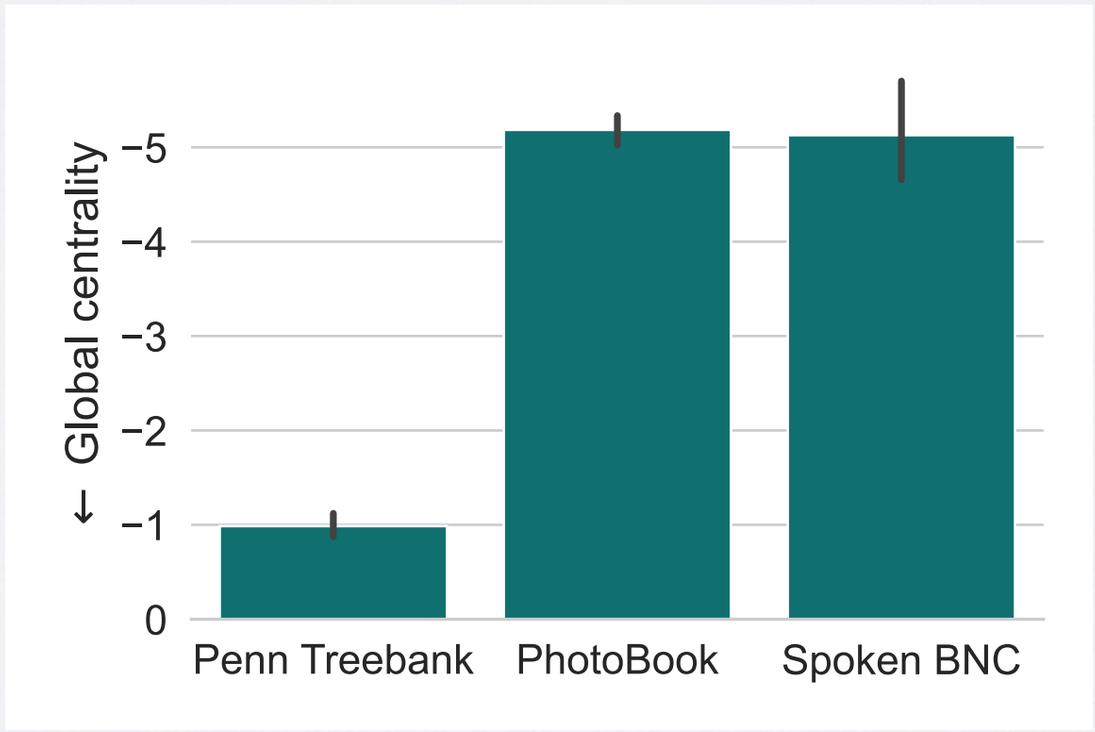

Experiment 2

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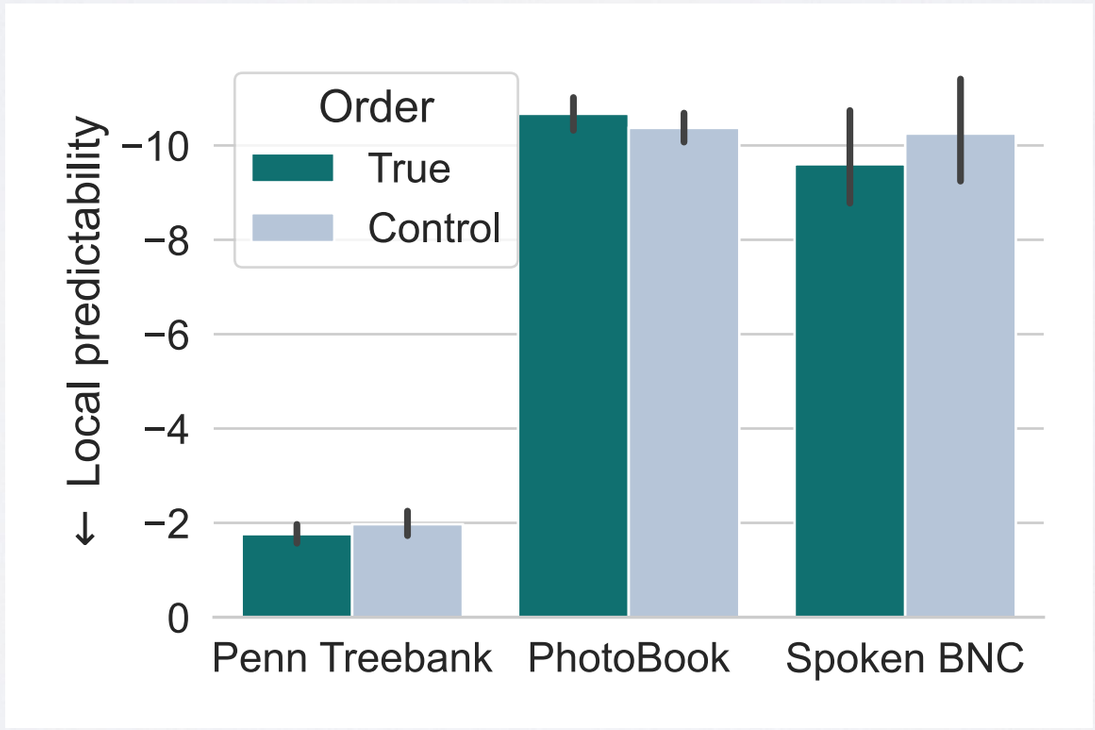

Summary

We have examined some central tenets of the classic information-theoretic model of communication.

We have used language models to obtain information content estimates for sentences *within their discourse context*.

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We have used language models to obtain information content estimates for sentences *within their discourse context.*

Findings

In newspaper articles information content remains stable, as predicted by the Entropy Rate Constancy principle.

This is not the case for spoken open domain dialogues, nor for written task-oriented dialogues.

Global uniformity is a more faithful criterion than local uniformity.

Discussion

Identifying the relevant components of discourse context

→ *Giulianelli, Sinclair, Fernández - EMNLP 2021*

Single vs. multiple addressees

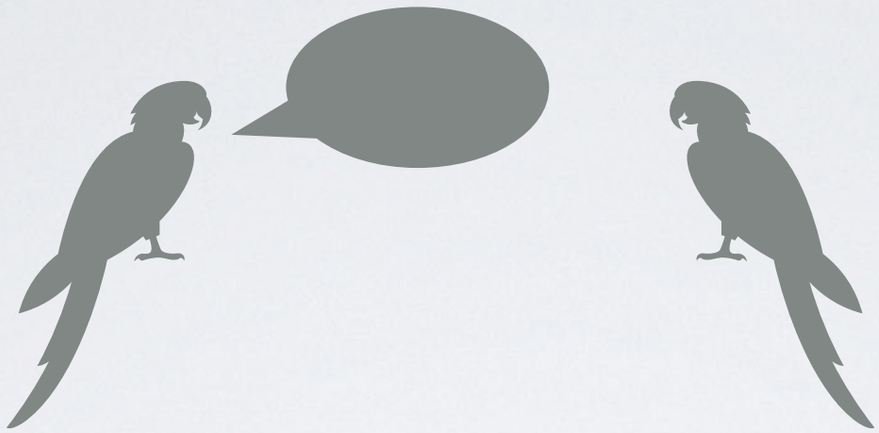
Production and comprehension effort conflated
in a single estimate

Architectures and training objectives to emulate the
organisation of information density found in human data

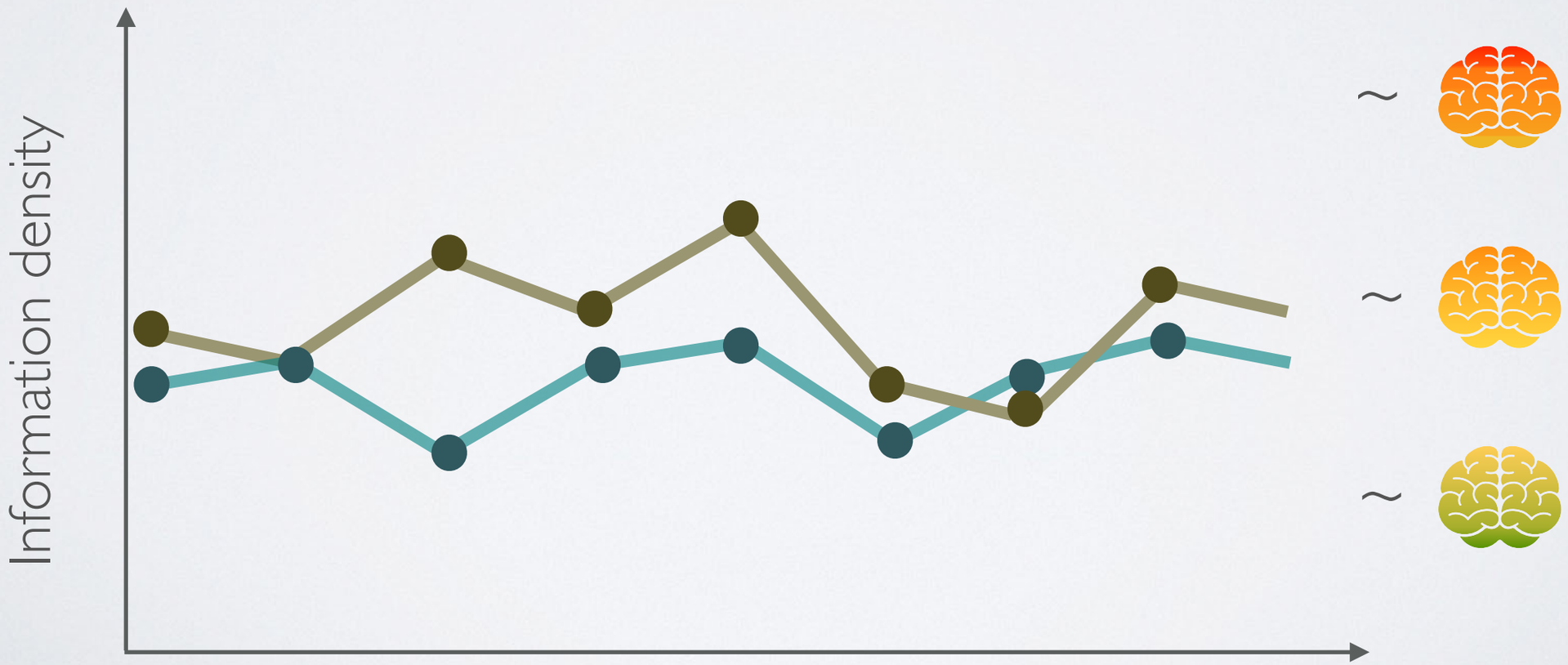
APPENDIX

Uniform Information Density

(Aylett & Turk, 2004; Jaeger & Levy, 2007)

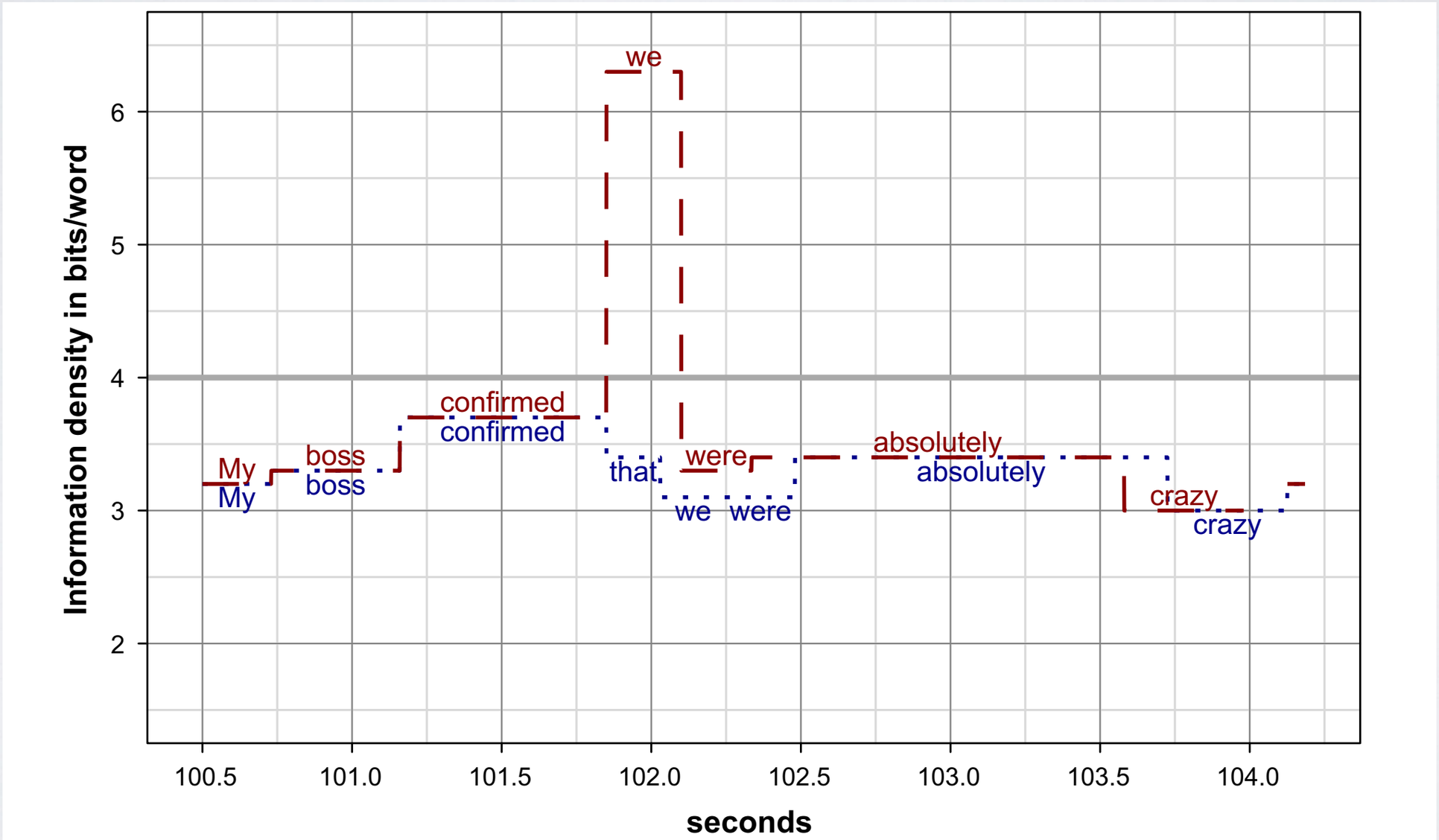


PROCESSING EFFORT



Uniform Information Density

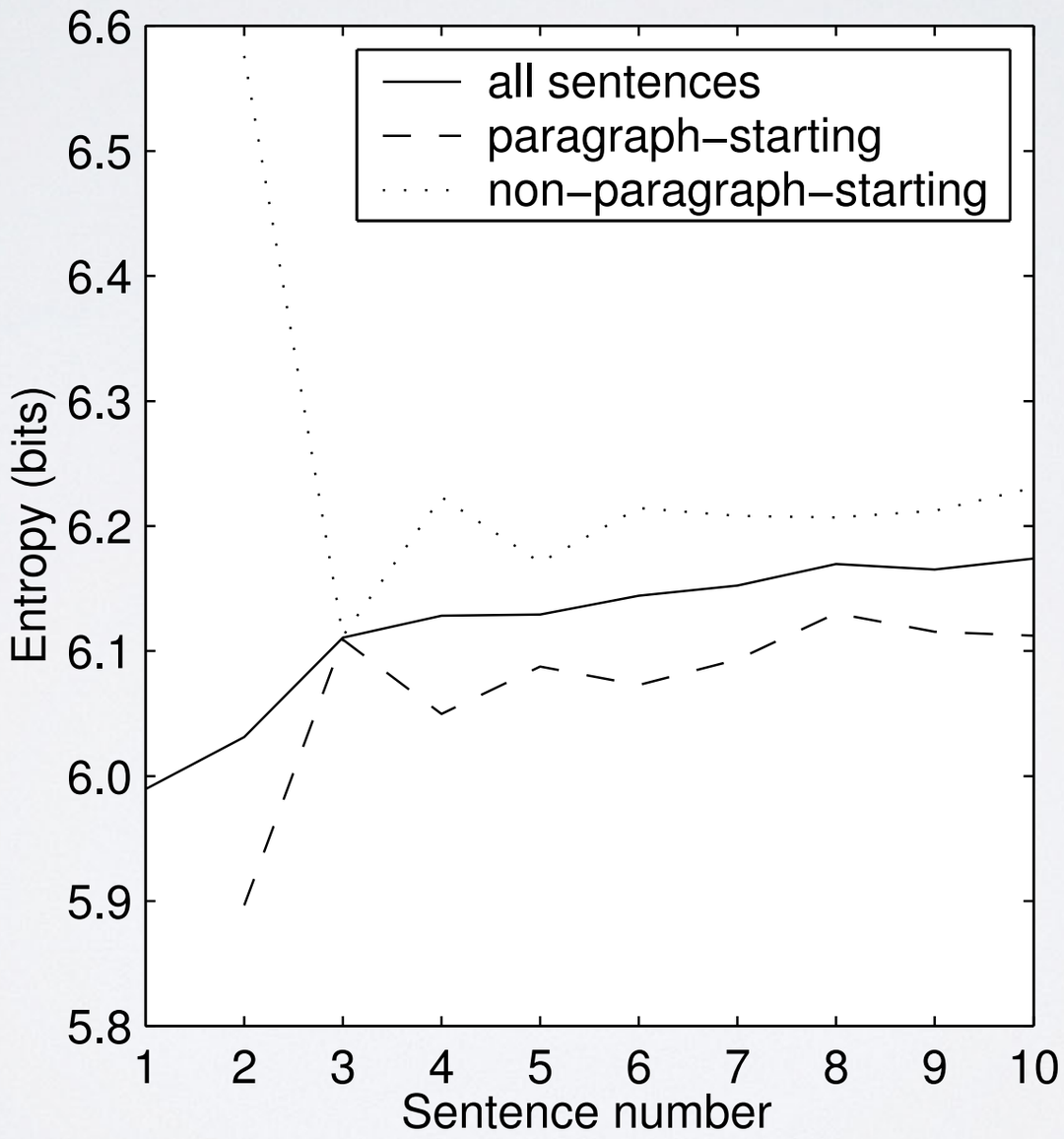
Example 1: Syntax
Complementiser *that*-mentioning (e.g., Jaeger , 2010)



(Jaeger , 2010; Figure 1a)

Uniform Information Density

Example 2: Discourse
Entropy rate constancy (Genzel & Charniak, 2002, 2003)



(Genzel & Charniak, 2003; Figure 1)

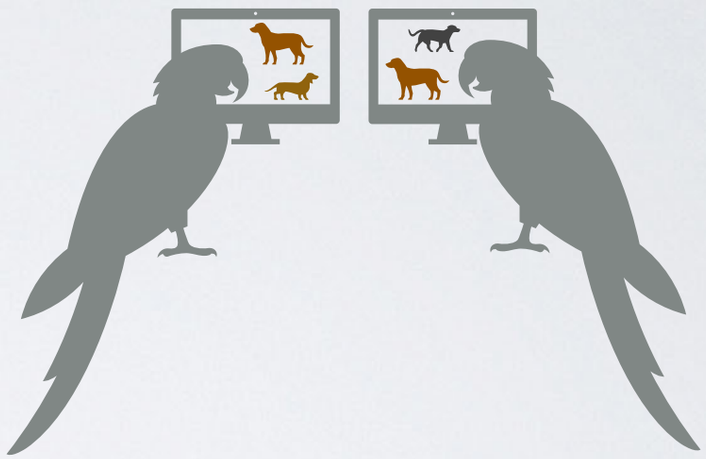
Task-oriented dialogue corpora

Round 3

B	pink sweater woman and man w/umbrella
A	yes
B	statue man with umbrella
A	y
B	guy in black suit with 2 plaid blue umbrellas
A	no

Round 4

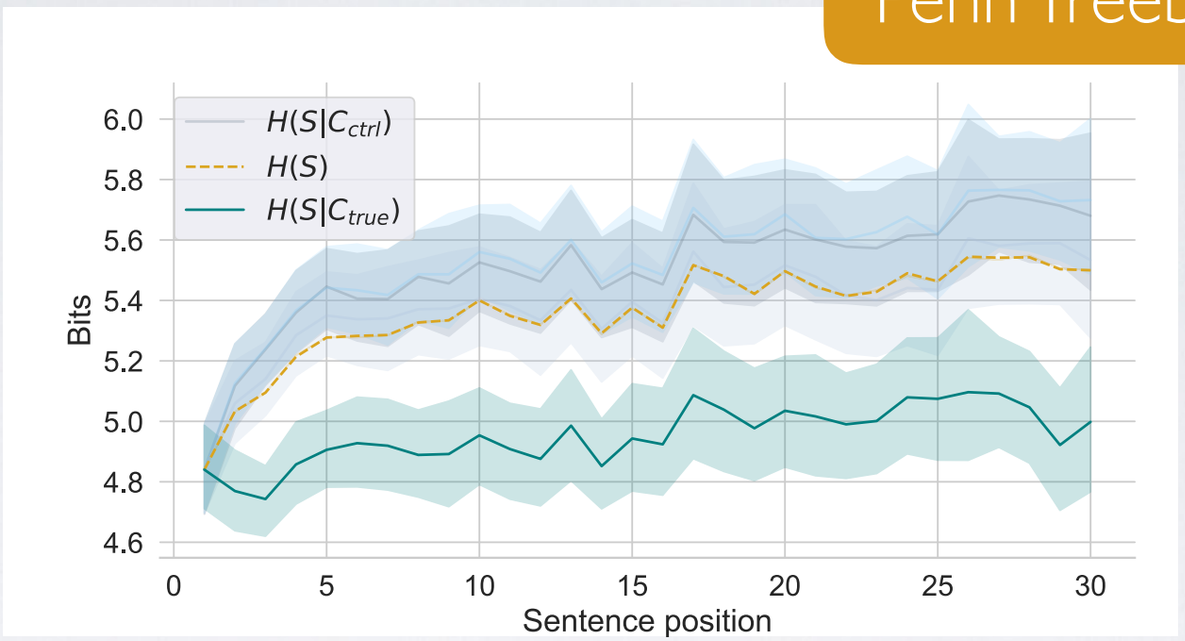
B	guy in black suit with 2 plaid blue umbrellas
A	no
B	lady in pink and guy with umbrella
A	no
B	statue/umbralla again
A	no



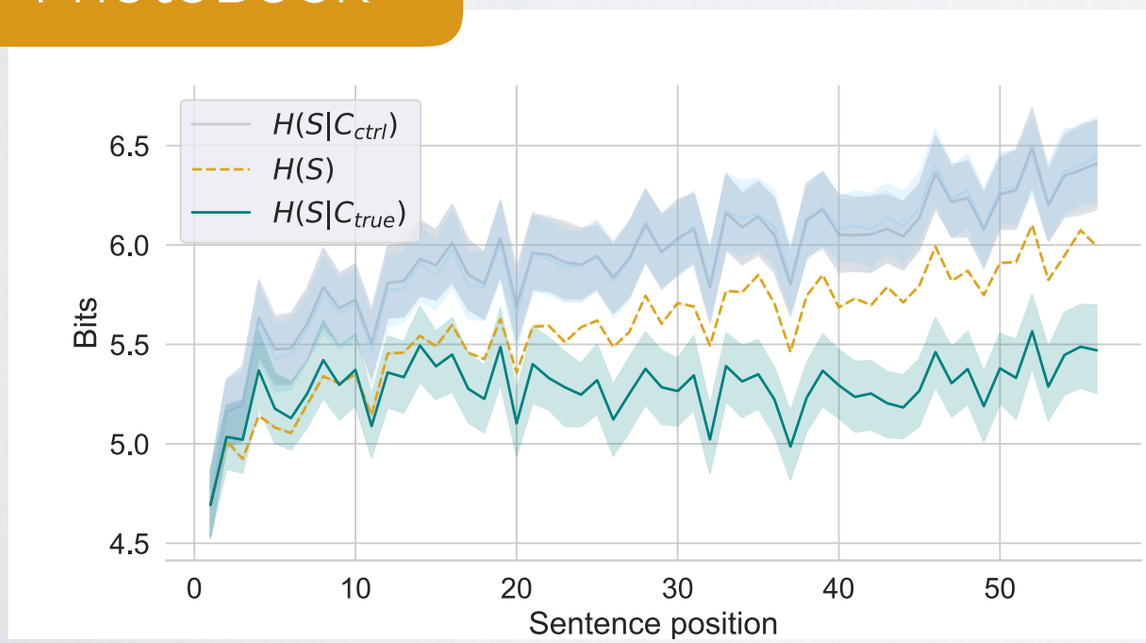
PhotoBook
written cooperative reference game
(Haber et al., 2019)

Control runs

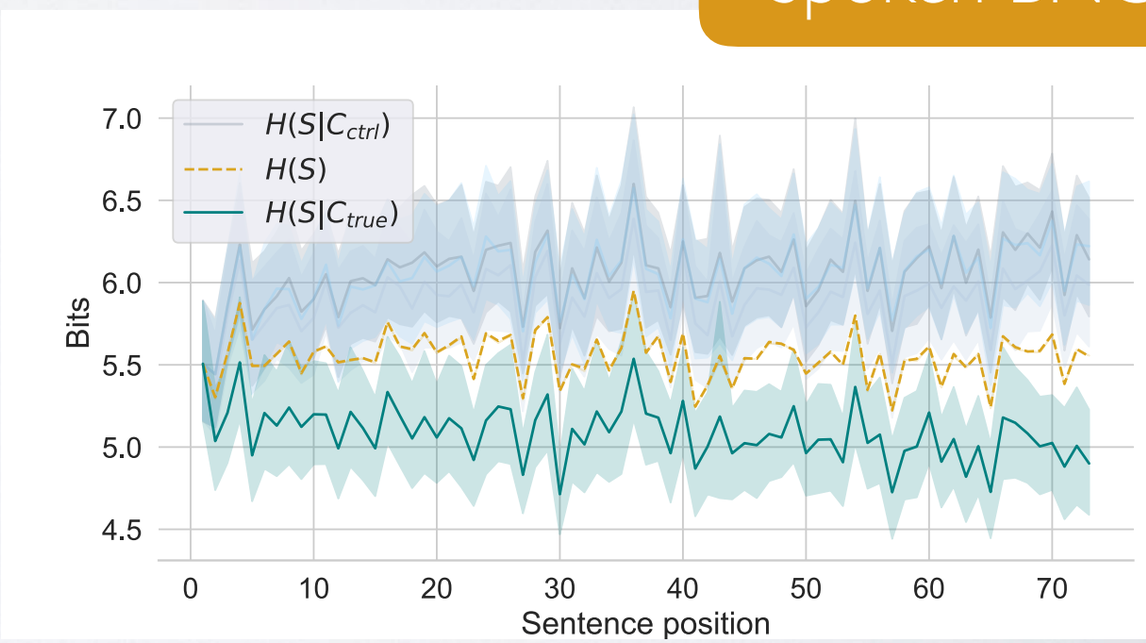
Penn Treebank



PhotoBook

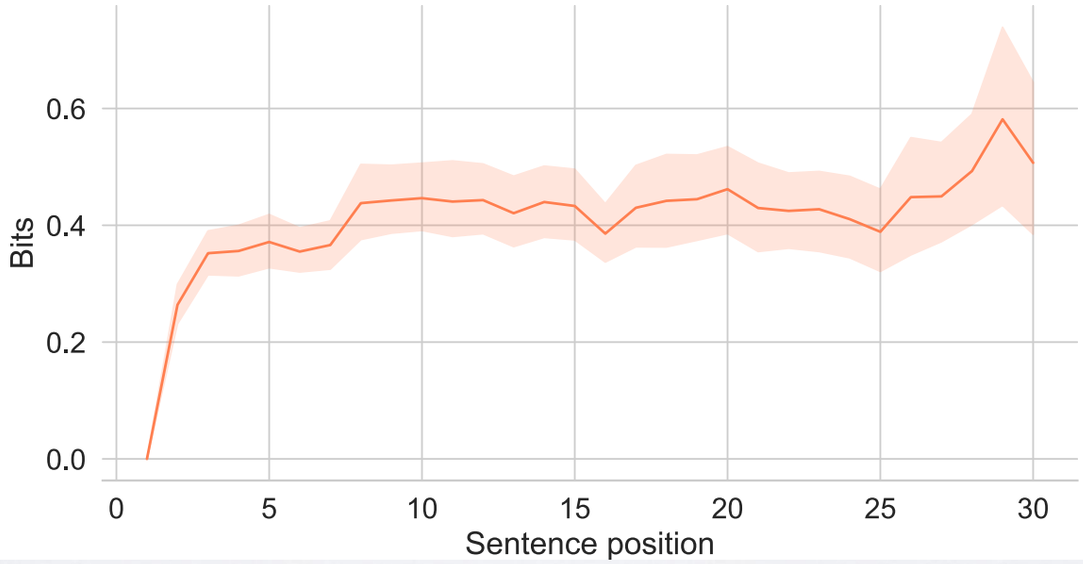


Spoken BNC



Context informativeness

Penn Treebank



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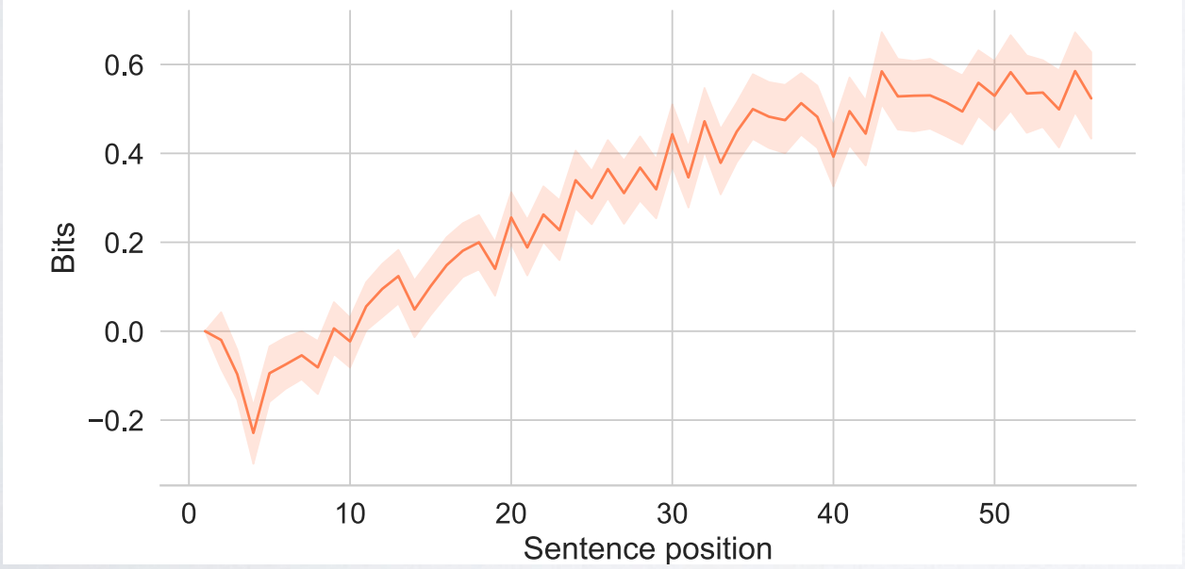

Spoken BNC