# Building A User-Centric and Content-Driven Socialbot

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# Agenda

- Background
- Sounding Board System – 2017 Alexa Prize Winner
- A Graph-Based Document Representation for Dialog Control
- Multi-Level Evaluation for Socialbot Conversations
- Summary and Future Directions

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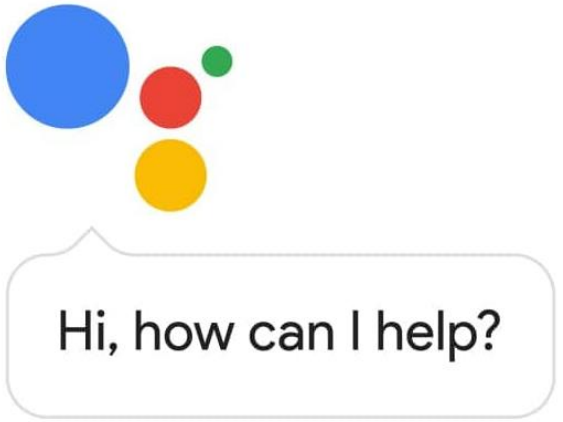
# Sci-Fi Movies

alexa



# Daily Life

# Types of Conversational AI

**Socialbots** *"converse coherently and engagingly with humans on popular topics and current events"*

Task Definition

task-oriented

non-task-oriented

Domain Coverage

single-domain

multi-domain

open-domain

Dialog Initiative

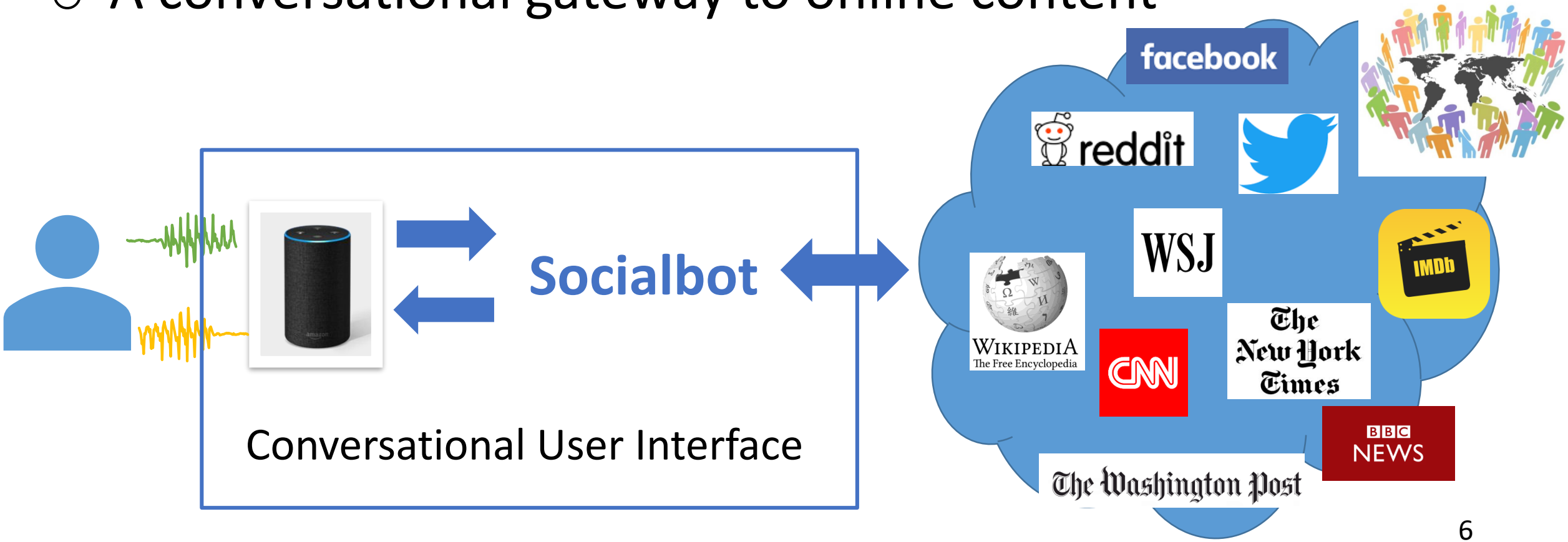
system-initiative

user-initiative

mixed-initiative

# Socialbot Applications

- Entertainment, education, healthcare, companionship, …
- A conversational gateway to online content



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# Design Objectives

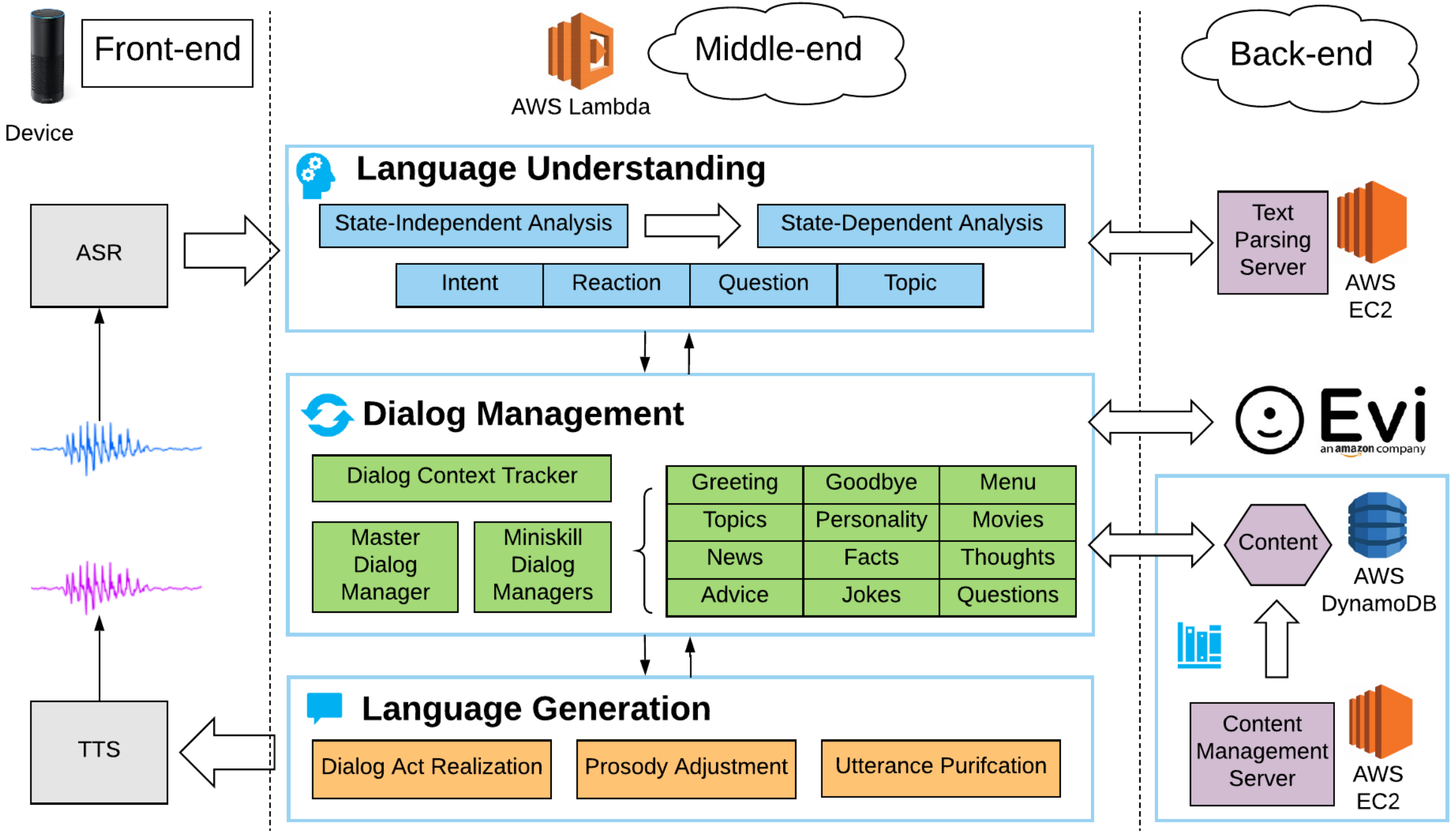
**User-Centric**

- Users can control the dialog flow and switch topics at any time
- Bot responses are adapted to acknowledge user reactions

**Content-Driven**

- Content cover the wide range of user interests
- Dialog strategies to lead or contribute to the dialog flow

# 2017 Alexa Prize Finals


Front-end
Device
AWS Lambda
Middle-end
Back-end
Language Understanding
State-Independent Analysis
State-Dependent Analysis
Intent
Reaction
Question
Topic
ASR
Text Parsing Server
AWS EC2
Dialog Management
Evi
an amazon company
Dialog Context Tracker
Master Dialog Manager
Miniskill Dialog Managers
Greeting
Goodbye
Menu
Topics
Personality
Movies
News
Facts
Thoughts
Advice
Jokes
Questions
Content
AWS DynamoDB
Language Generation
Dialog Act Realization
Prosody Adjustment
Utterance Purifcation
Content Management Server
AWS EC2
TTS

# Dialog Control for Many Miniskills?

Conversation Activities (Miniskills)

- Greet
- List Topics
- Tell Fun Facts
- Tell Jokes
- Tell Headlines
- Discuss Movies
- Personality Test
- …

# Hierarchical Dialog Management

- Dialog Context Tracker
  - dialog state, topic/content/miniskill history, user personality
- Master Dialog Manager
  - miniskill polling
  - topic and miniskill backoff
- Miniskill Dialog Managers
  - miniskill dialog control as a finite-state machine
  - retrieve content & build response plan

# Social Chat Knowledge

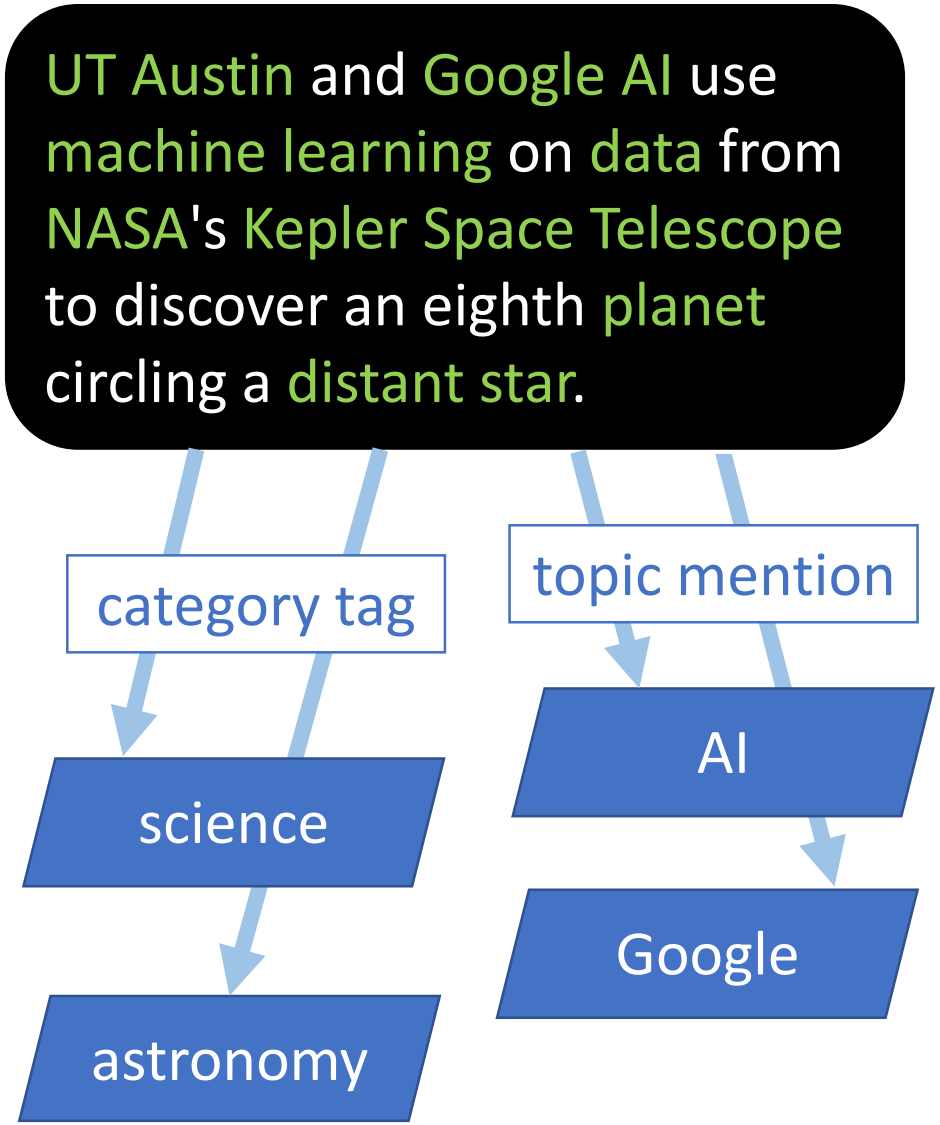

An important type of social chat knowledge is online content.

How to organize content to facilitate the dialog control?

A framework that allows dialog control to be defined in a consistent way.

# Knowledge Graph

- Nodes
  - content post (fact, movie, news article, …)
  - topic (entity or generic topic)
- Relational edges between content post and topic
  - topic mention (NER, noun phrase extraction)
  - category tag (Reddit meta-information)
  - movie name, genre, director, actor (IMDB)
- Dialog Control: move along edges



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# Motivation

Graph-Based Document Representation

- Dialog control defined based on moves on the graph
  - lead the conversation
  - handle user initiatives
- Challenges for unstructured document (e.g., news articles)
  - not all sentences are equally interesting to a listener
  - need to figure out a coherent presenting order
  - answer questions about the document
  - need a smooth transition between sentences
  - handle entity-based information seeking requests
  - handle opinion-seeking requests

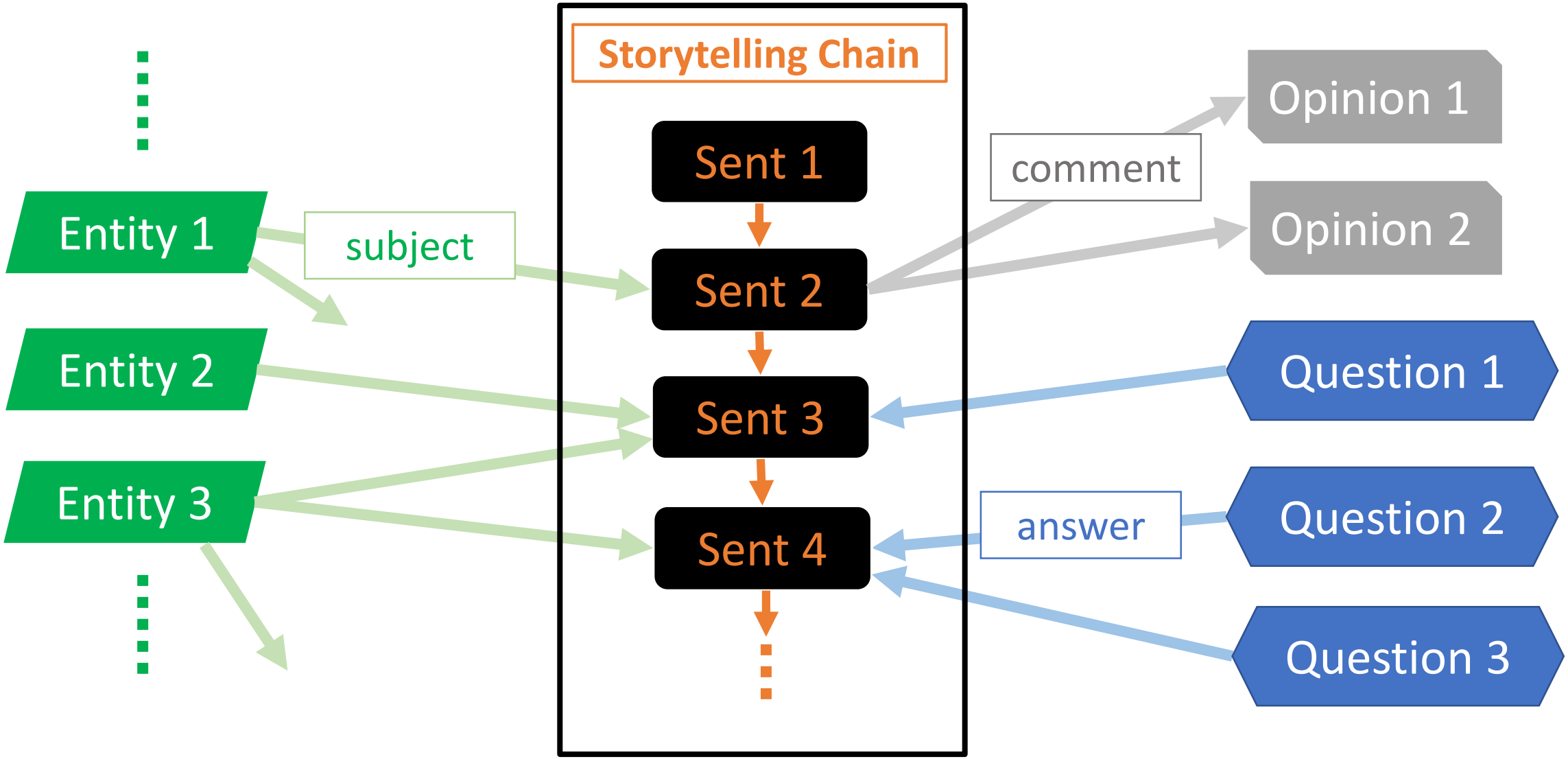
Storytelling

Question Answering & Asking

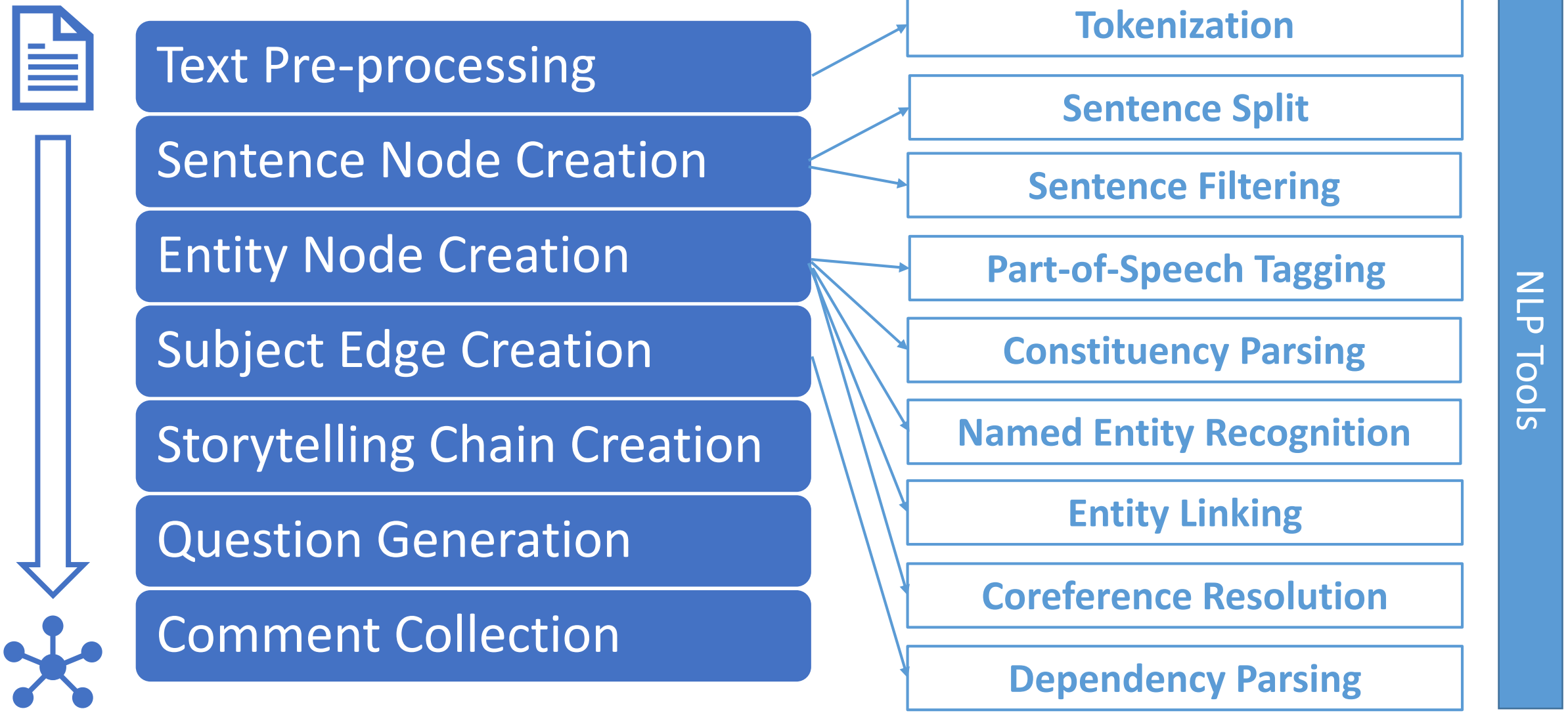
Subject Entity

Opinion Comment

# Graph-Based Document Representation



# Document Representation Construction

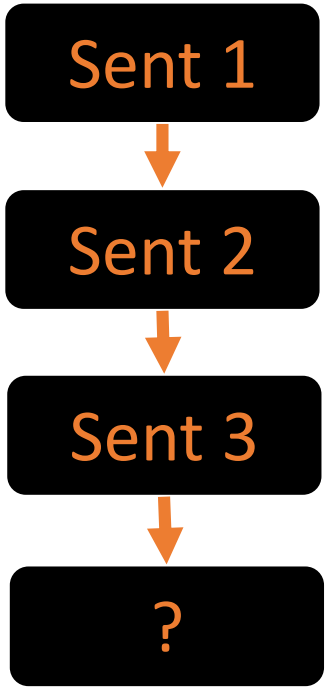


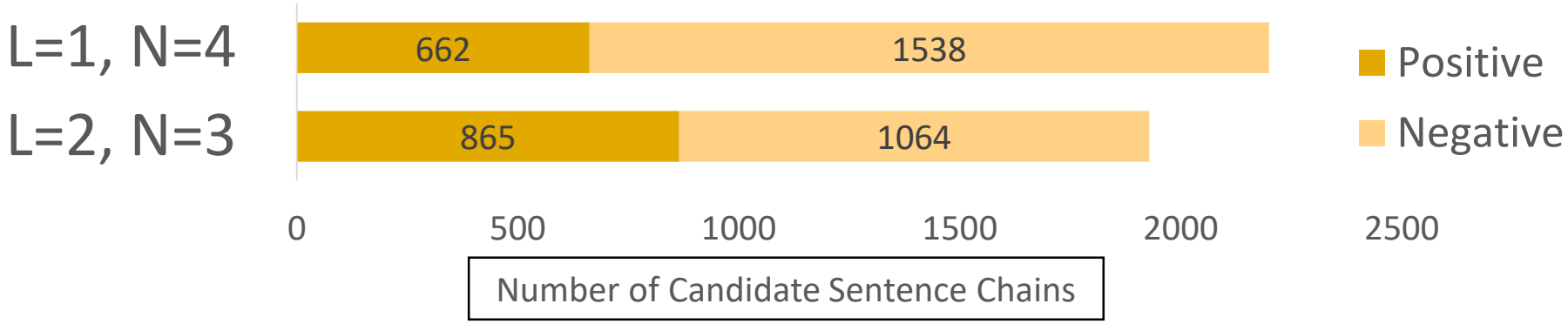
# Storytelling Chain Creation

- Problem formulation
  - context sentence sequence $(s_1, s_2, \dots, s_L)$
  - candidate sentence set $\{y_1, y_2, \dots, y_N\}$
  - candidate sentence chain $(y_i \mid s_1, s_2, \dots, s_L)$
- Data collection: 550 news articles
  - Train/Validation/Test: 3/1/1 based on article ID

the next $N$ sentences following $s_L$ in the article

Binary Label



# Model and Features

- Model: binary logistic regression
  - input: candidate sentence chain $(y_i \mid s_1, s_2, \ldots, s_L)$
  - output: probability score $s(y_i \mid s_1, s_2, \ldots, s_L) \in \mathbb{R}^{[0,1]}$

used for ranking sentences given $s_1, s_2, \ldots, s_L$

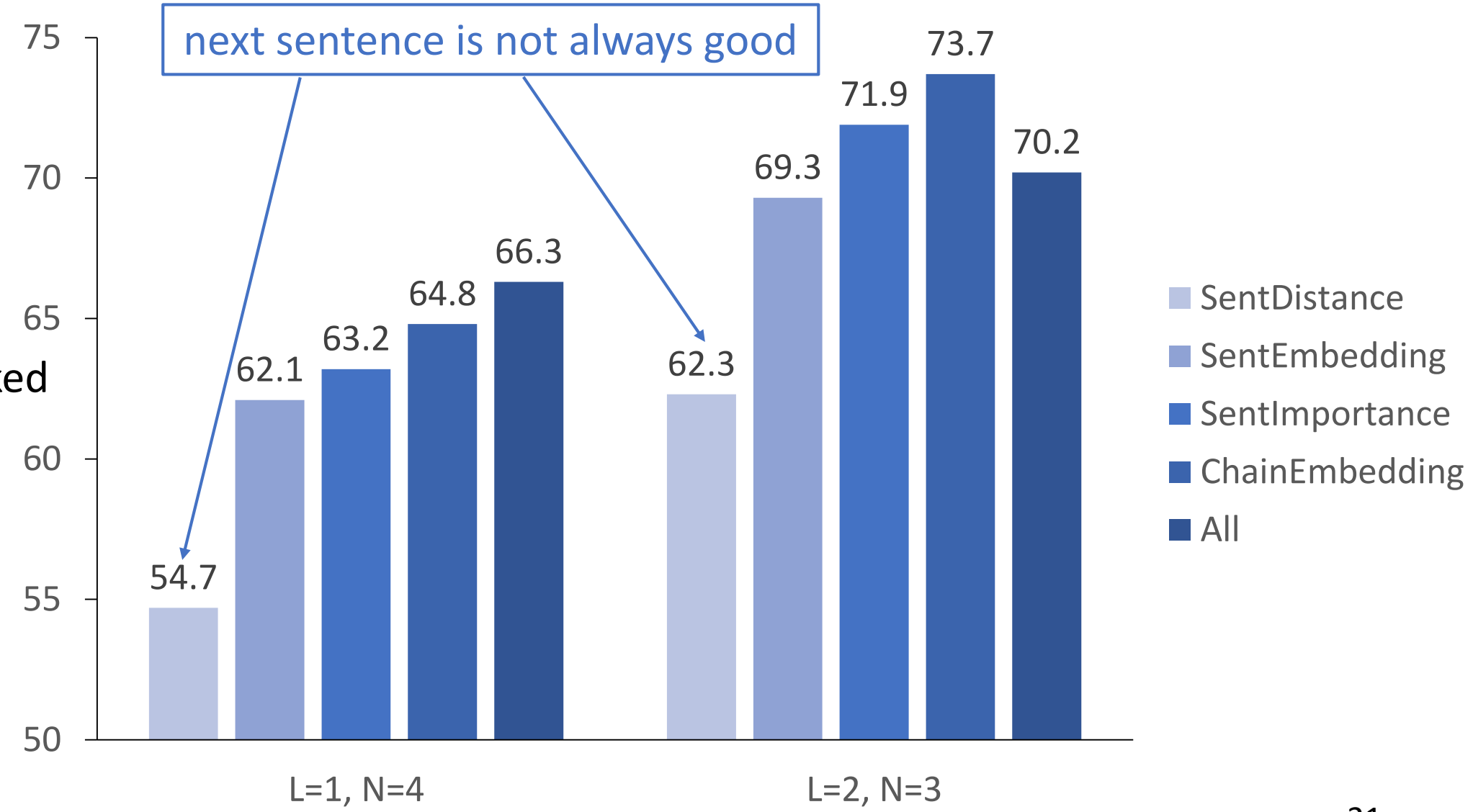
- Features
  - SentImportance: $r(y_i \mid D)$
  - SentDistance: $d(y_i \mid s_1, s_2, \ldots, s_L) = SentIdx(y_i) - SentIdx(s_L)$
  - SentEmbedding: $e(y_i)$
  - ChainEmbedding: $c(y_i \mid s_1, s_2, \ldots, s_L)$

TextRank unsupervised summarization on the document $D$

Pre-trained BERT

# Test Set Results

% the highest-ranked sentence has a positive label



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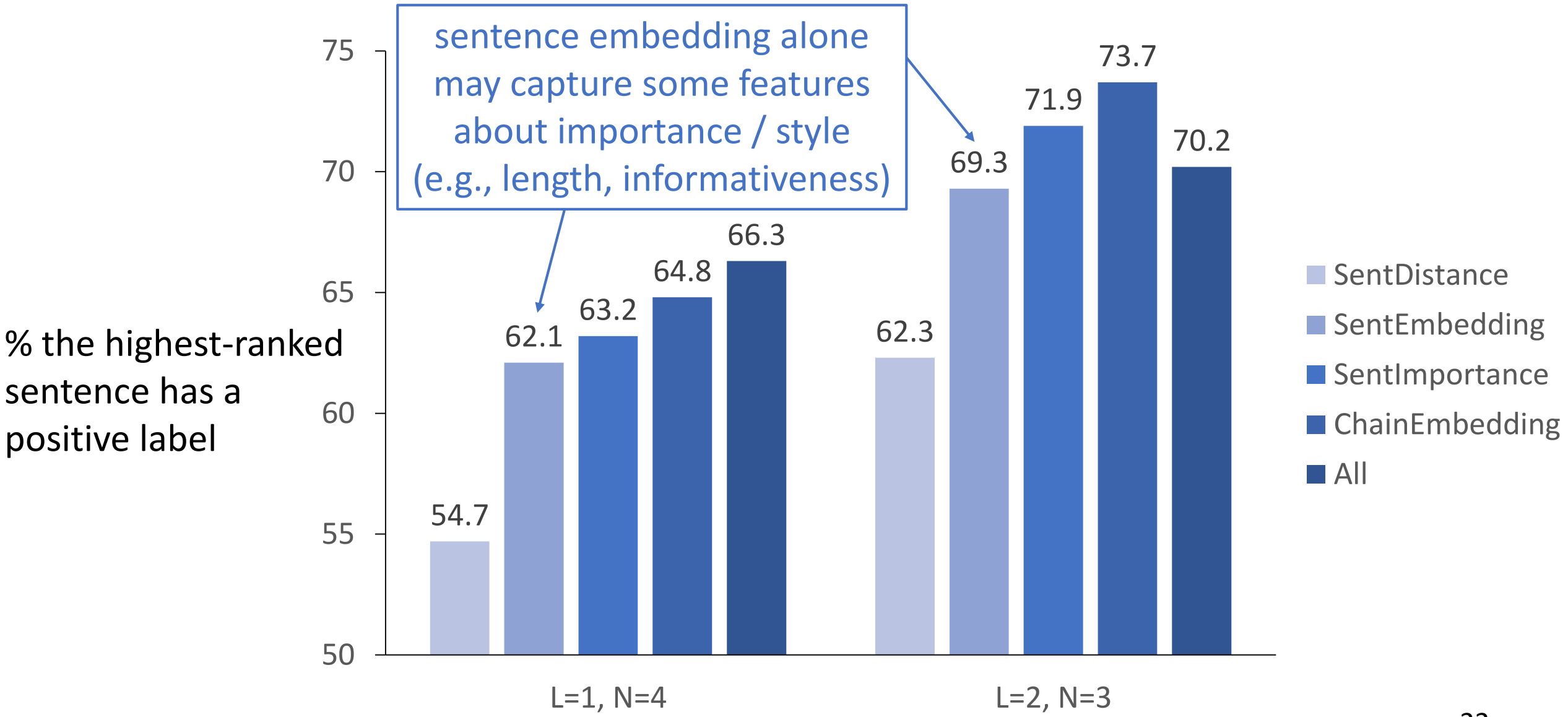

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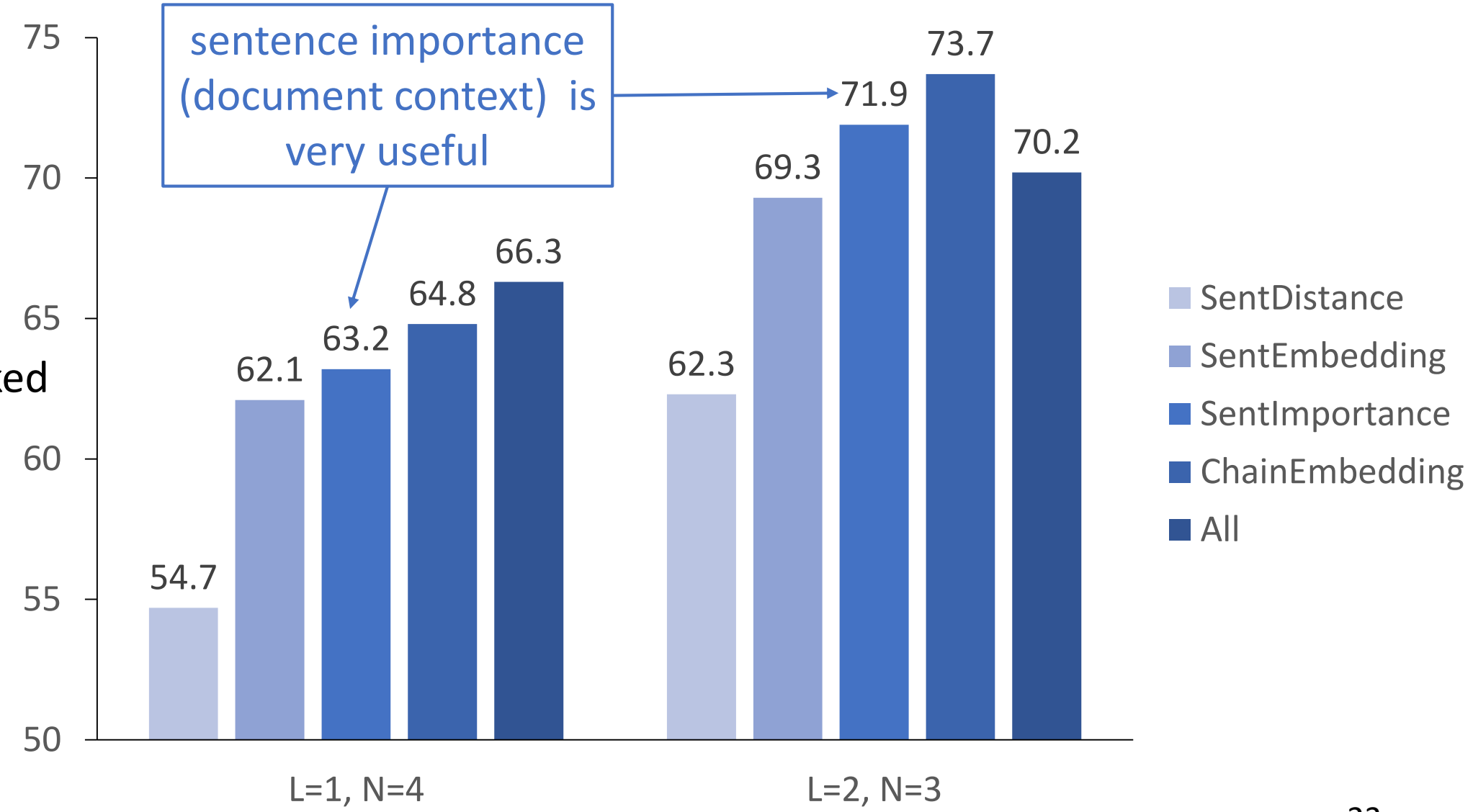

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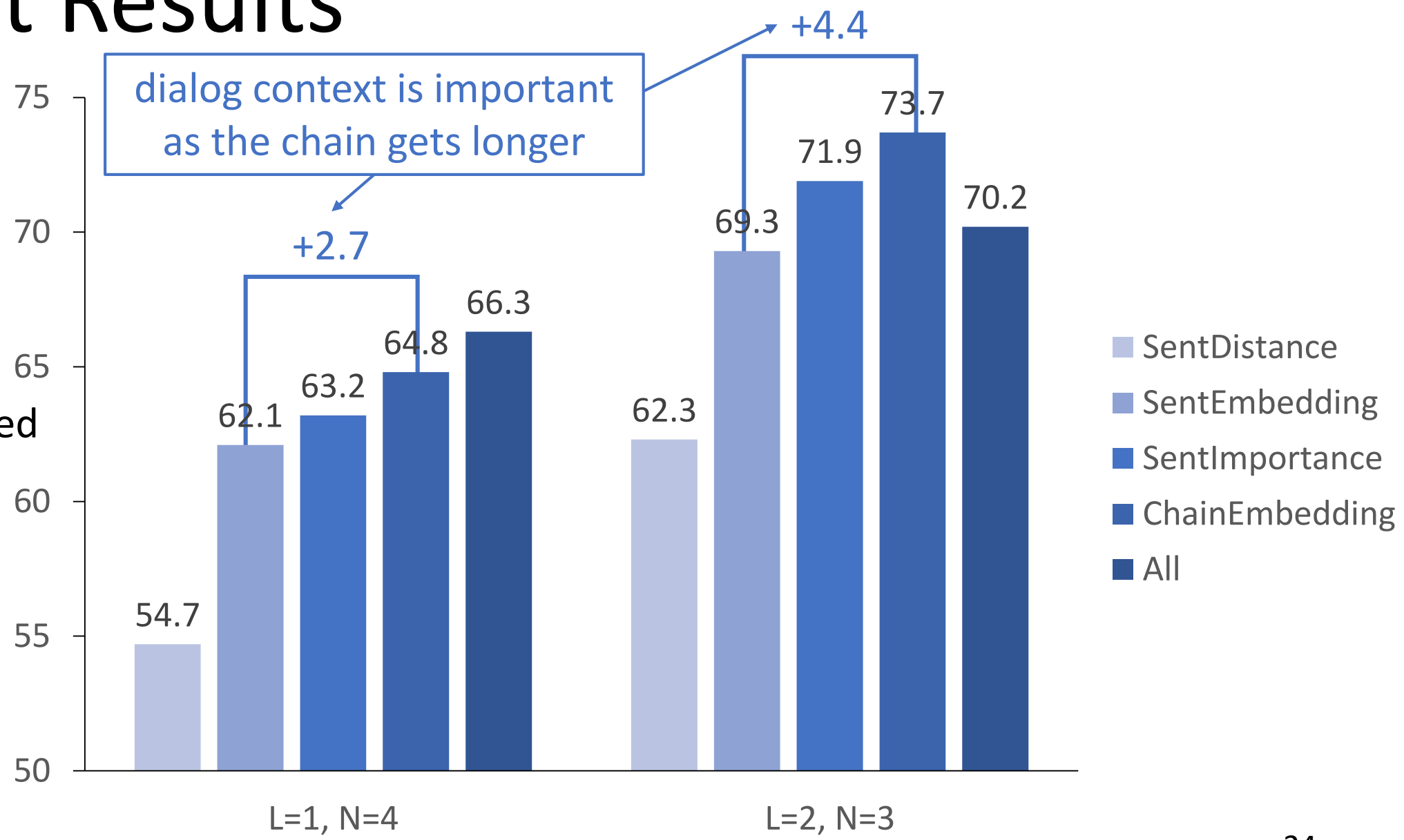
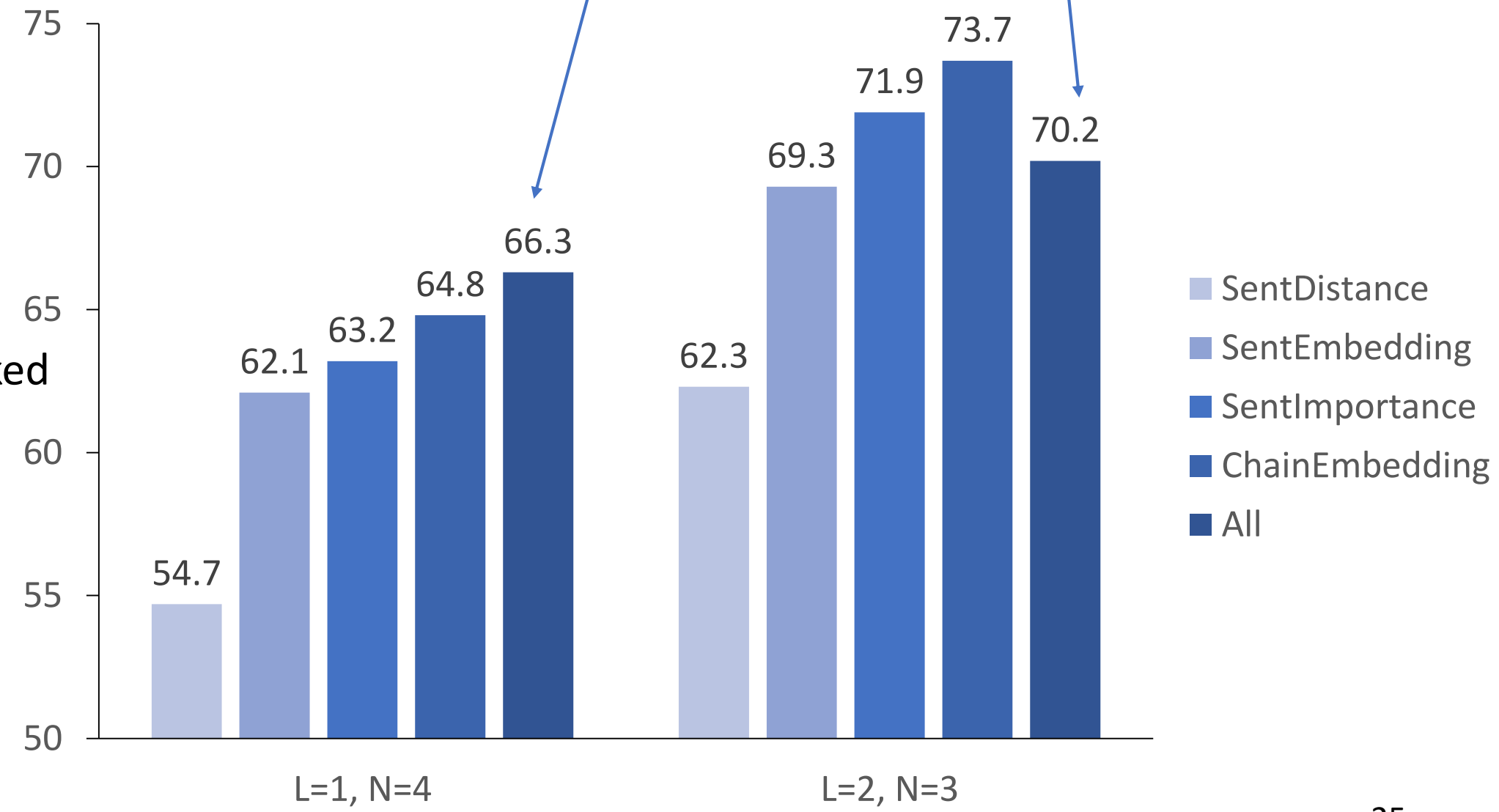


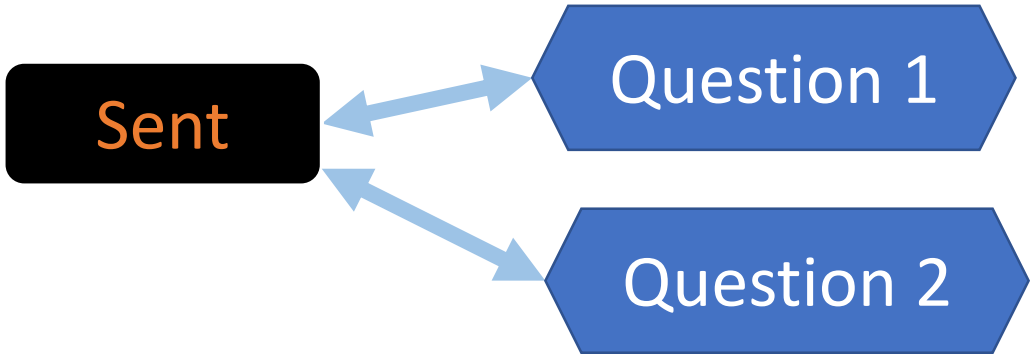
# Test Set Results

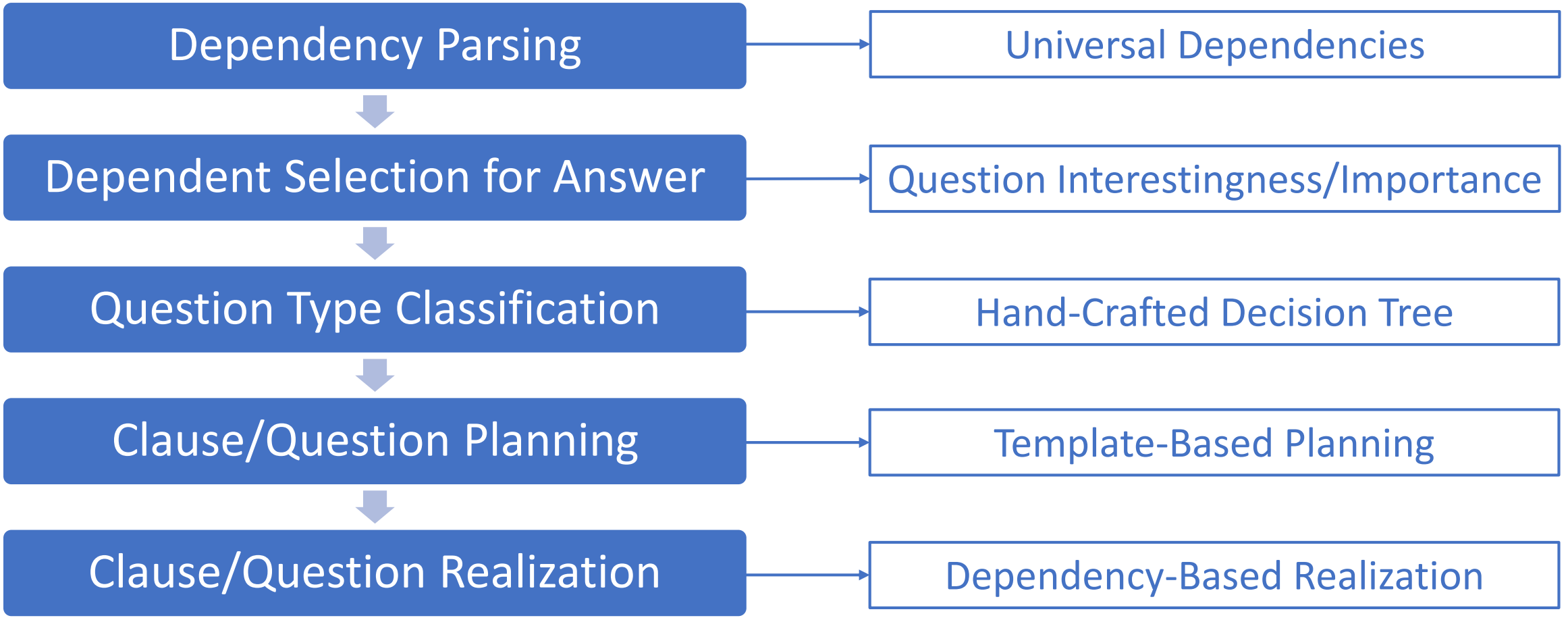
using all features (2050-dimensional) overfits for L=2 (1239 training samples)

% the highest-ranked sentence has a positive label



# Question Generation



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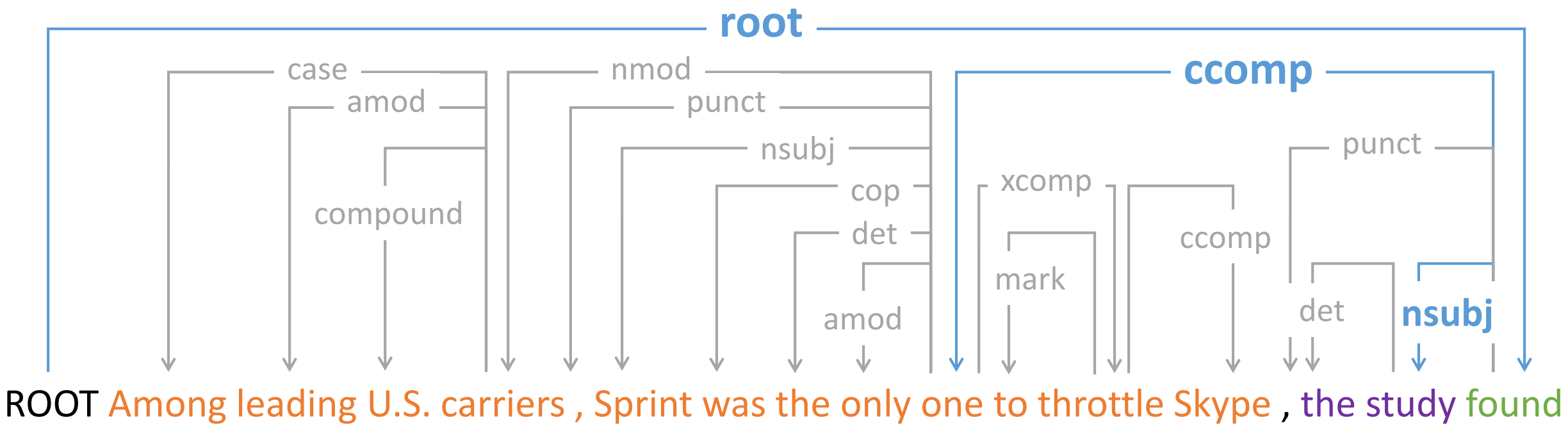
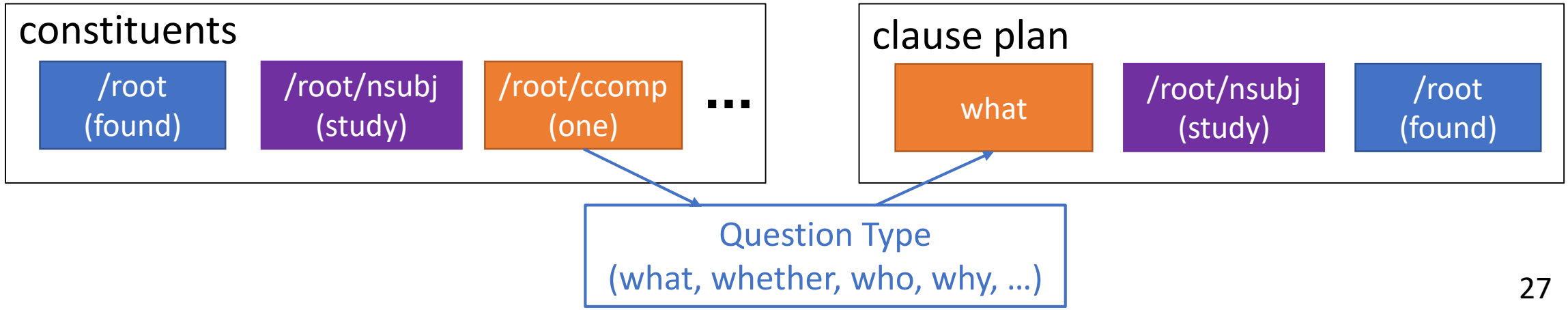
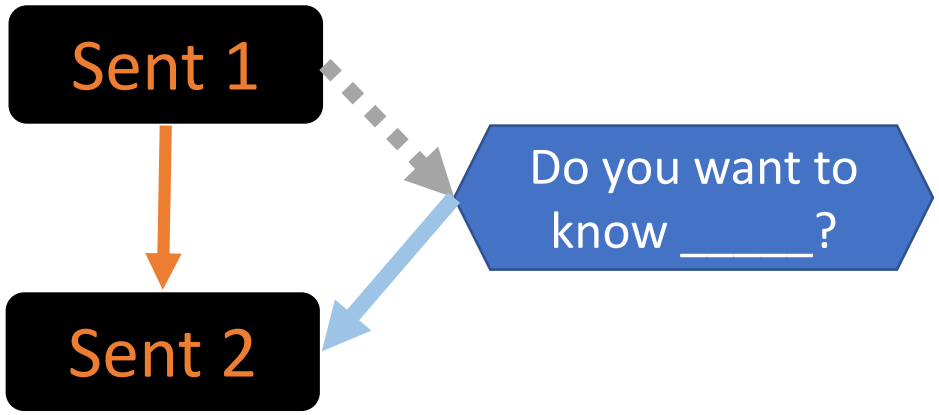


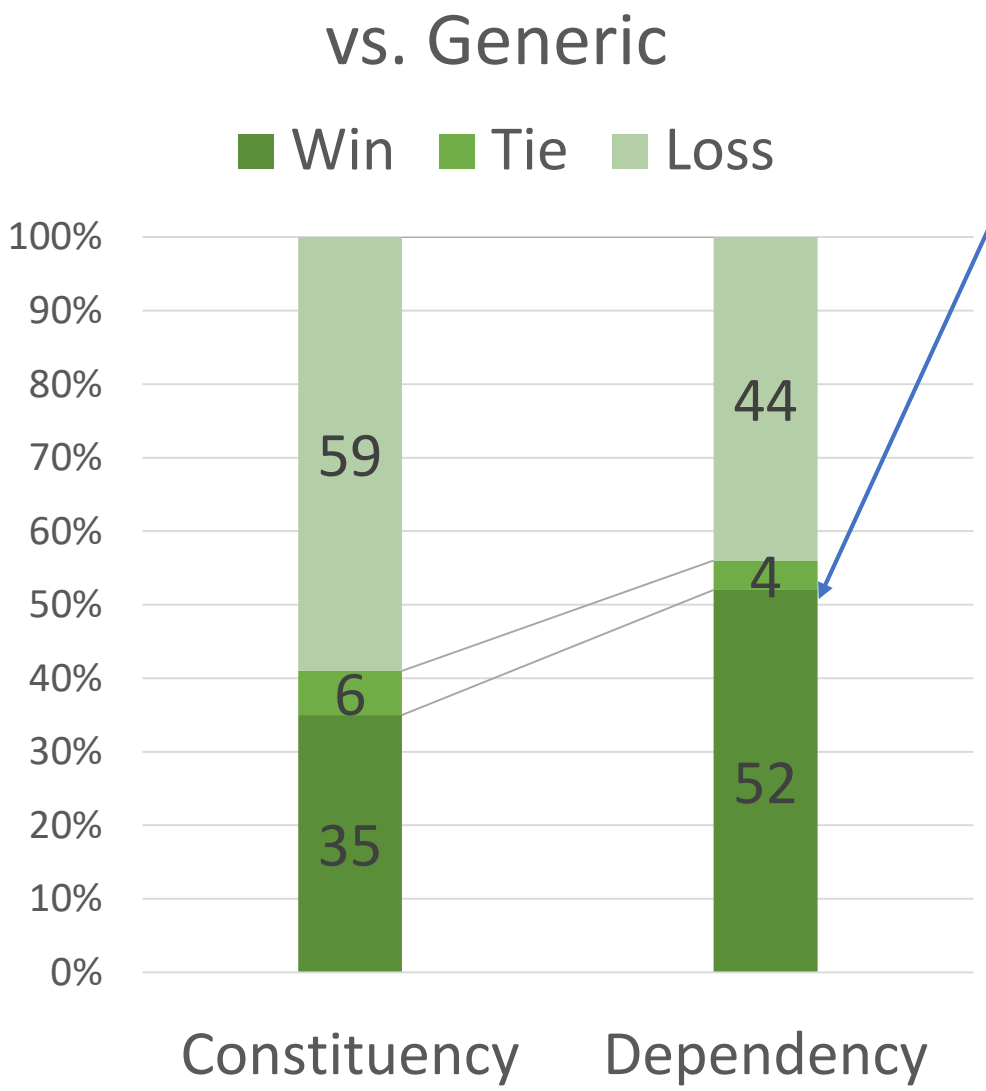
# Evaluation of Generated Questions

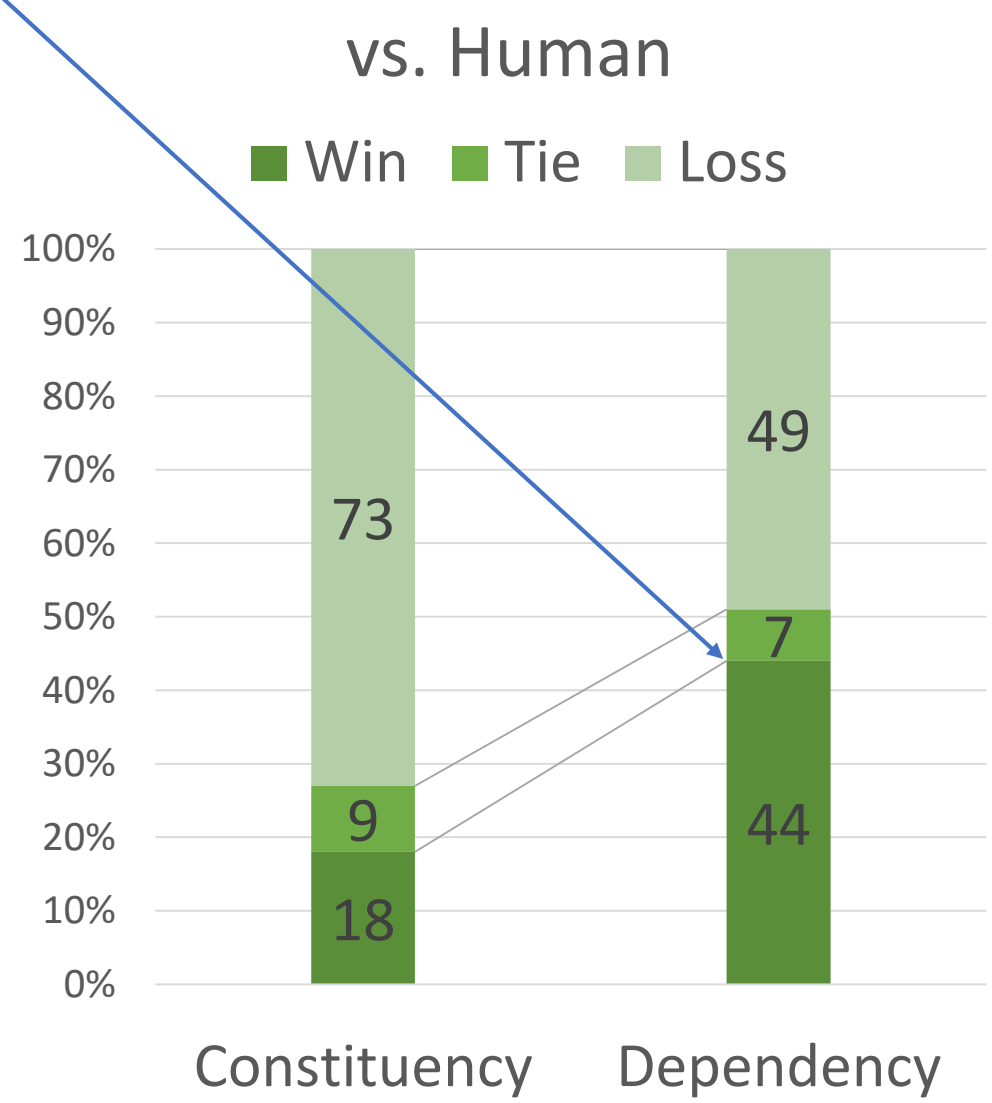
- As a transition clause for introducing Sent2 given Sent1
  - *do you want to know _____?*
- 4 question generation methods
  - generic: *more about this article*
  - constituency-based (Heilman, 2011)
  - dependency-based
  - human-written
- Human judgments on question pairs (A, B, cannot tell)
  - 134 sentences, 5 judgments per pair



# Overall Quality

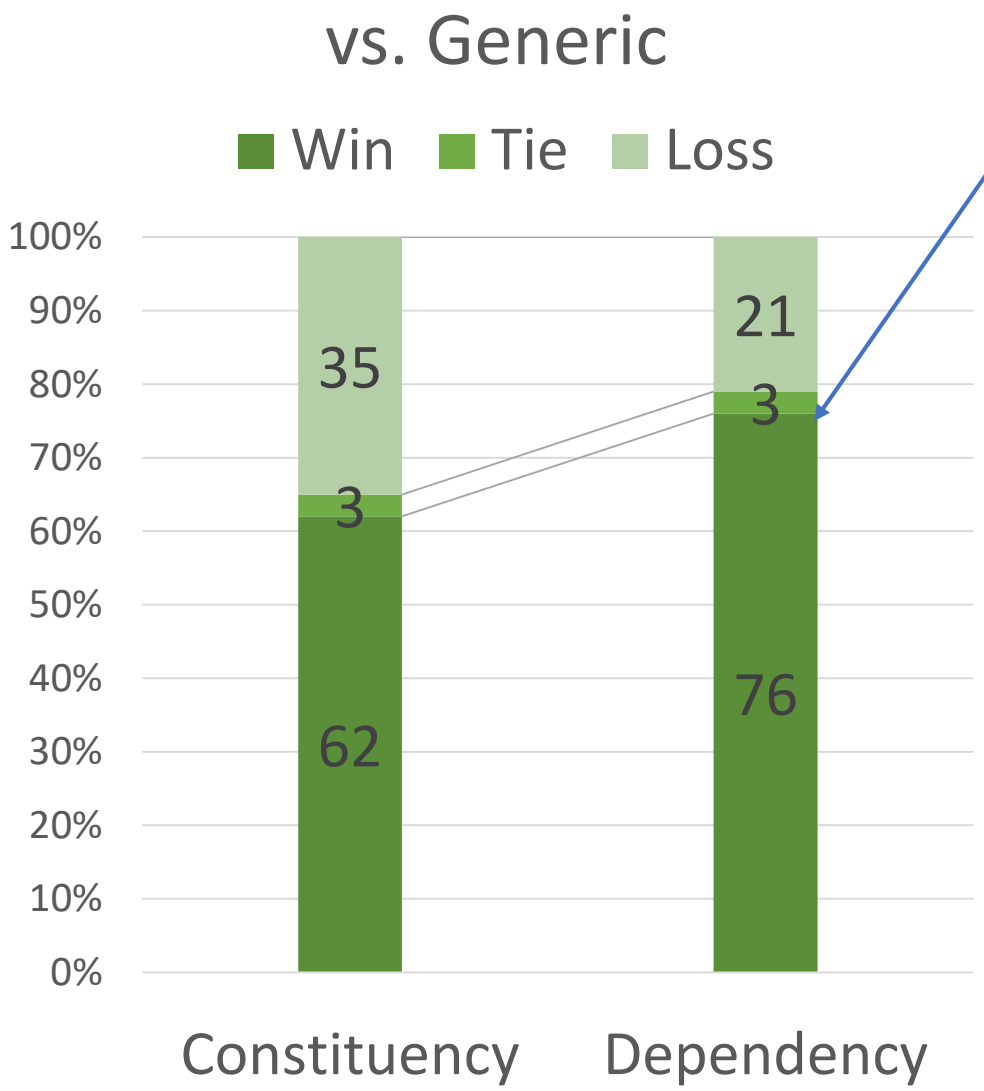
dependency-based outperforms constituency-based, but does not achieve “human performance”

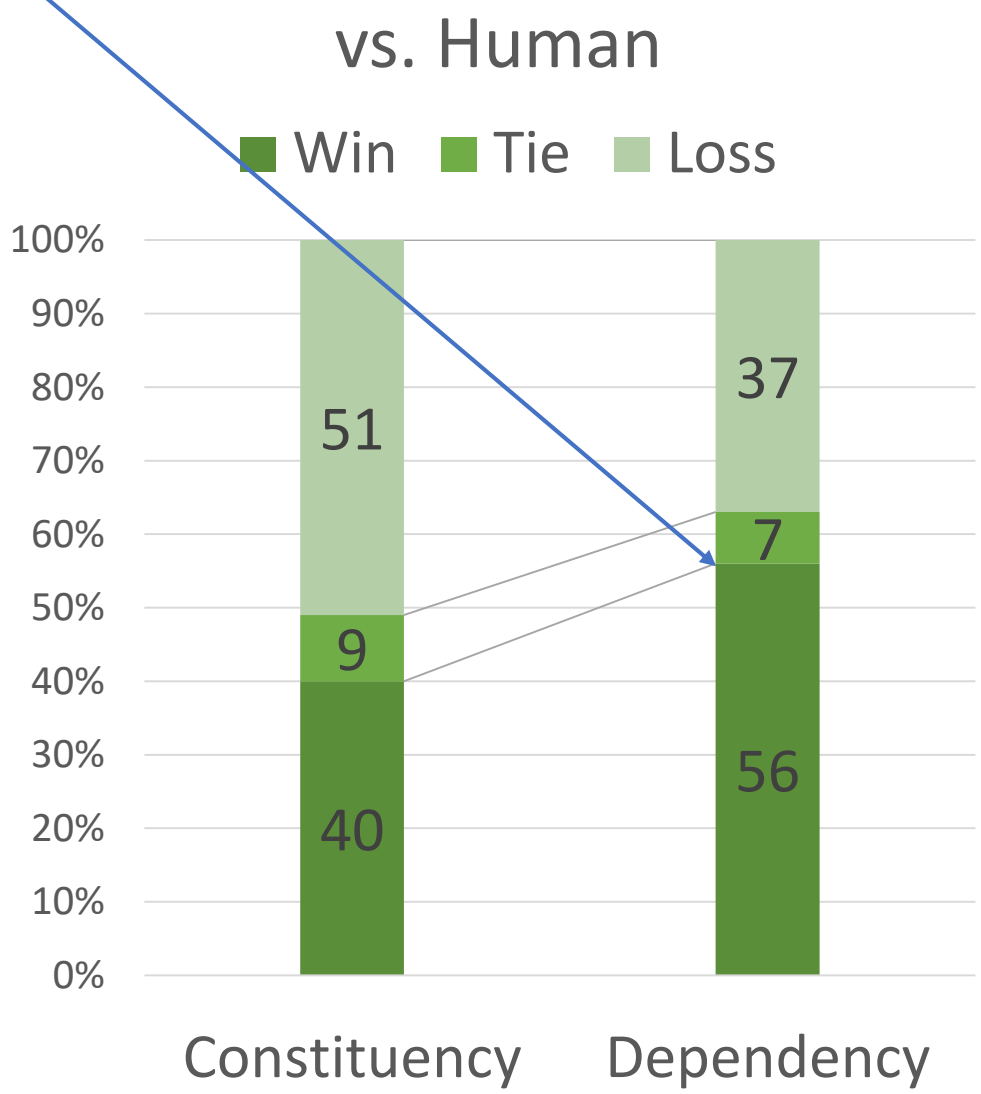


# Informativeness

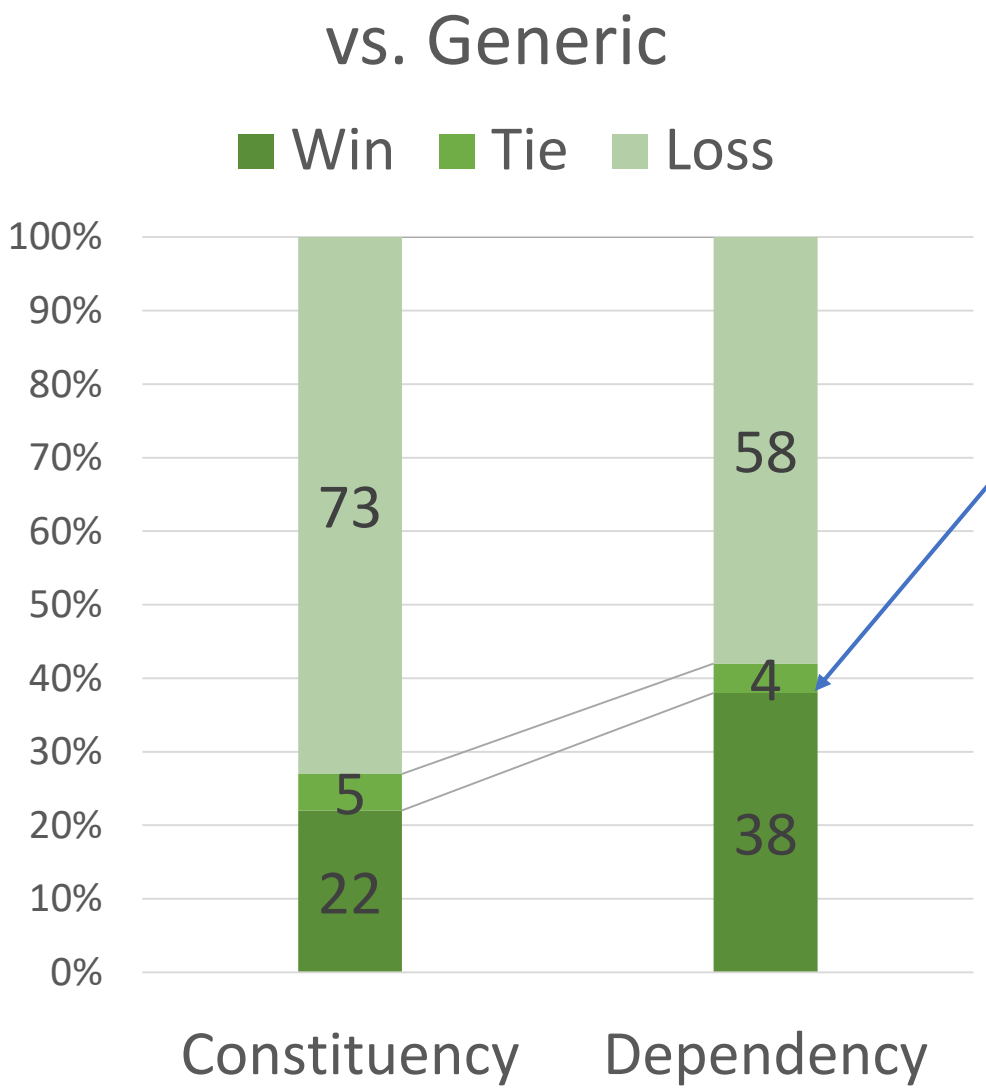
dependency-based method generates much more informative questions (better than human)

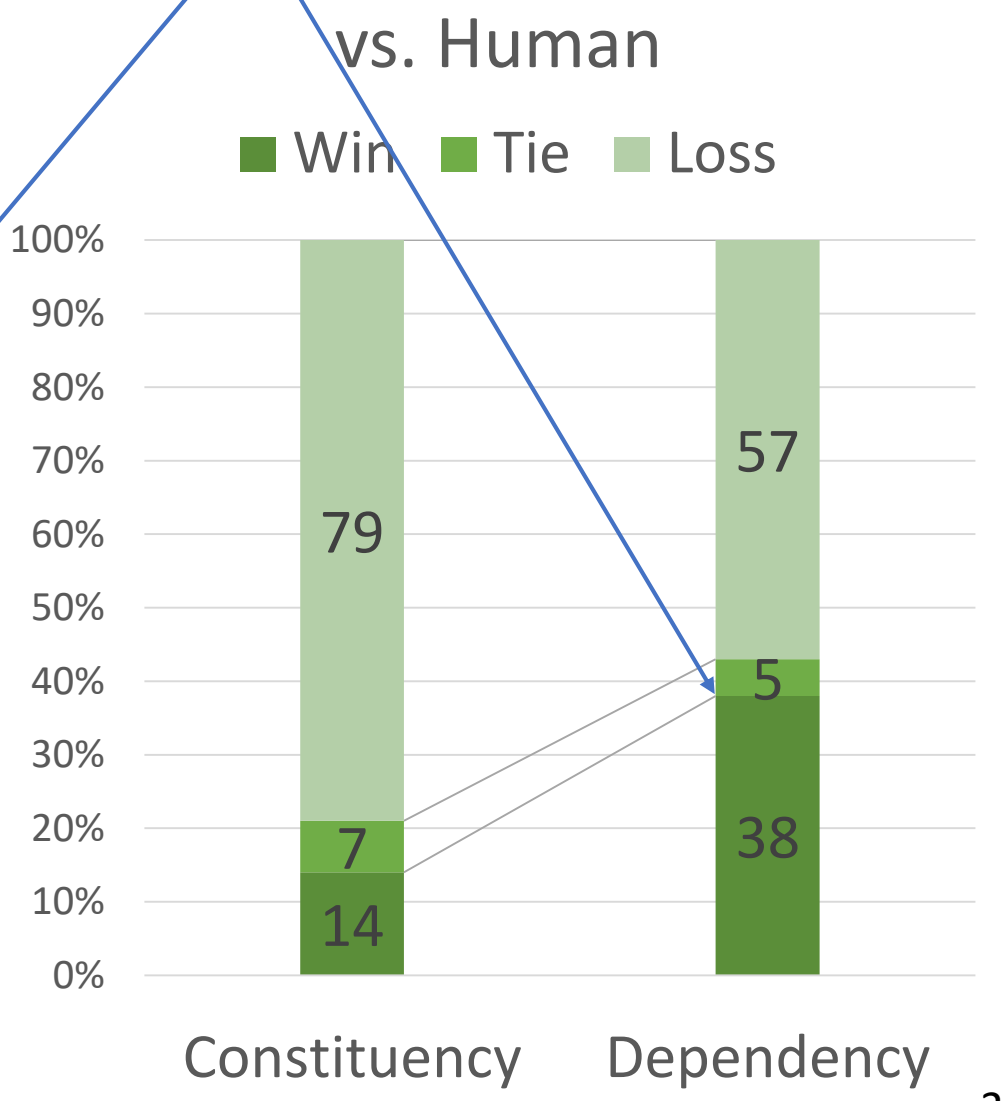


# Transition Smoothness

dialog context is important!



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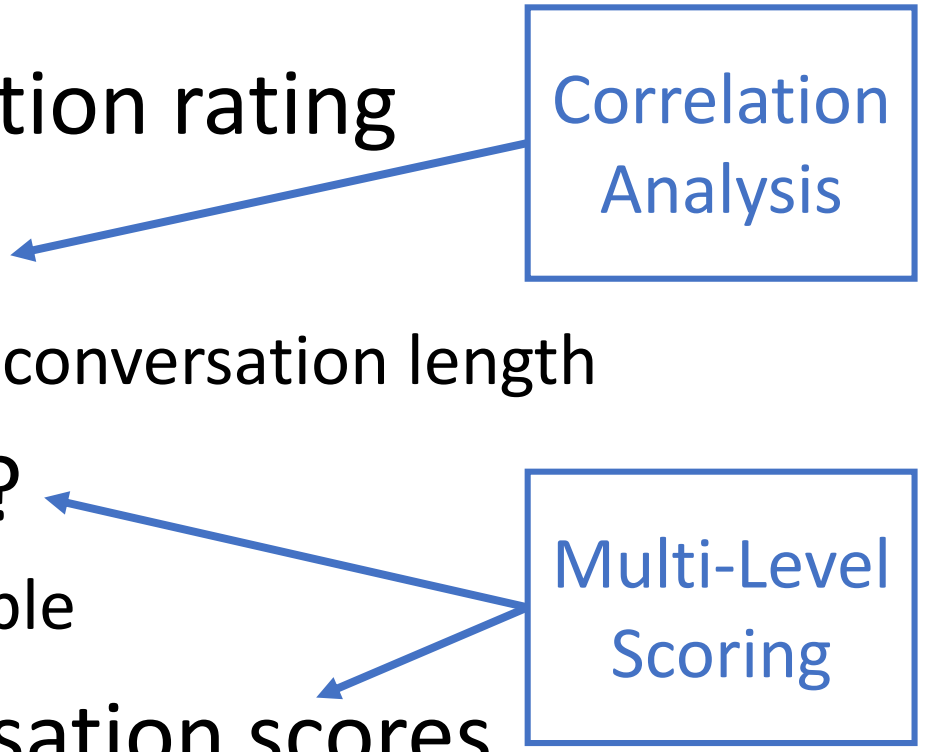
# Motivation: Evaluation & Diagnosis

- Users only give an optional conversation rating
- Aspects that influence user ratings?
  - prior model-free metrics do not outperforms conversation length
- Structure of socialbot conversations?
  - prior models of dialog structure are not suitable
- Diagnosis calls for more than conversation scores
  - a conversation can involve good and bad segments/topics/policies/…



# Conversation Acts for User Turns

- AskQuestion
- RequestHelpOrRepeat
- ProposeTopic
- AcceptTopic
- RejectTopic
- FollowAndNonNegative

Rule-Base Tagging

- InterestedInContent
- NotInterestedInContent
- PositiveToContent
- NegativeToContent
- PositiveToBot
- NegativeToBot

Model-Base Tagging

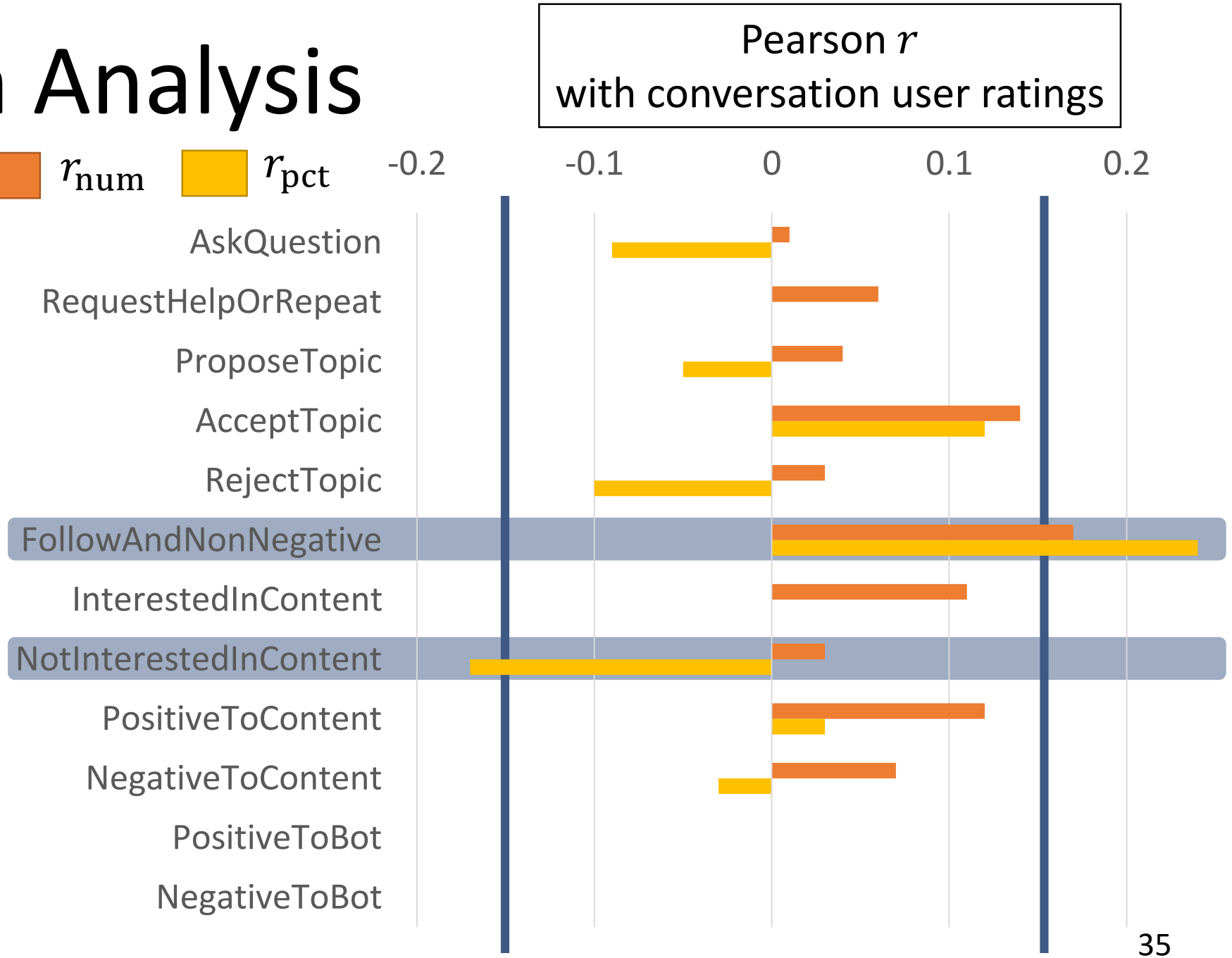
# Correlation Analysis

For each act $A$

- number of turns $N_A$
- percentage of turns $P_A$

$N_A$ cannot tell any negative correlation

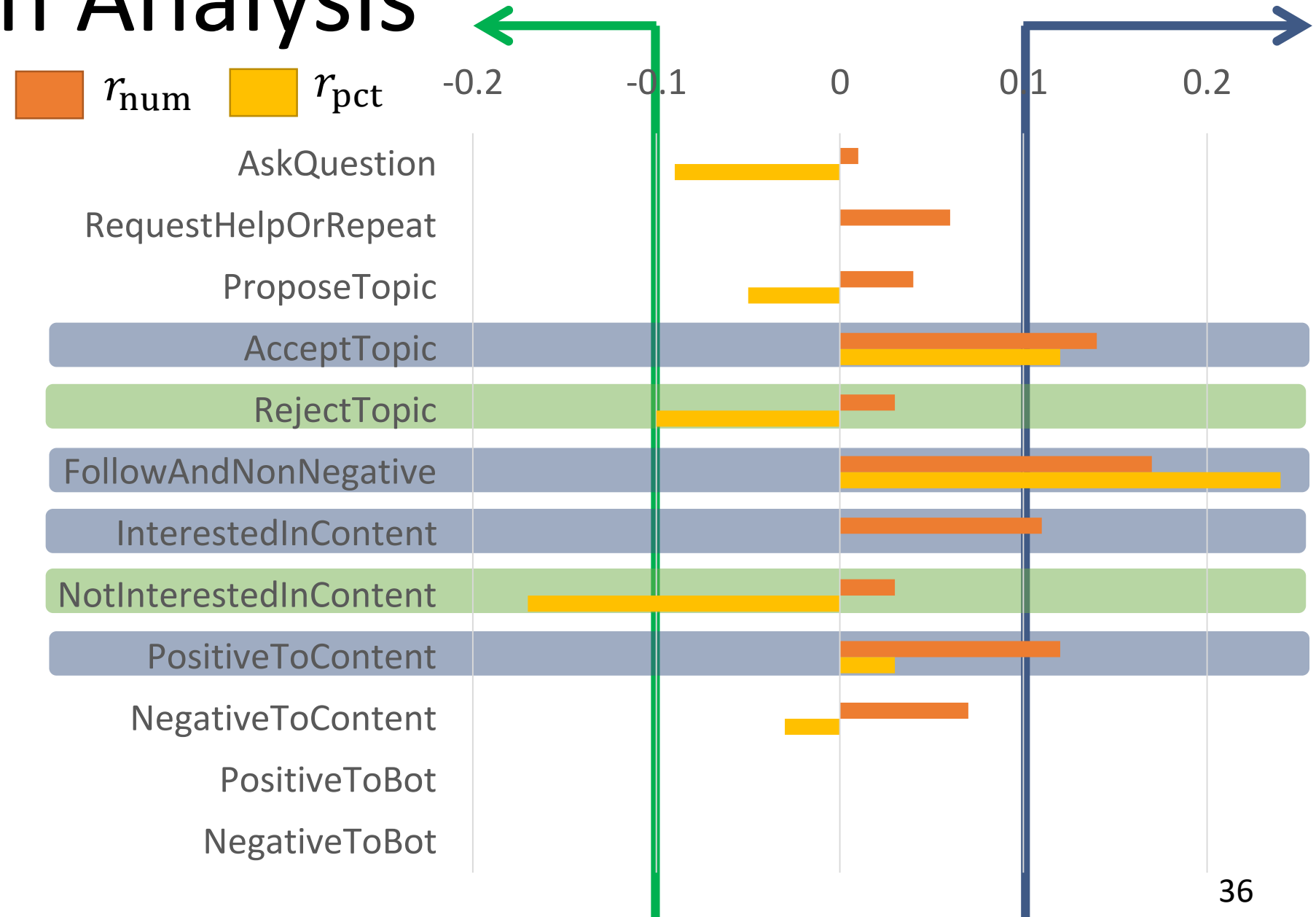
Conversation Length
$r$ = 0.15



# Correlation Analysis

It is a good sign that user follows the conversation flow when the bot is the primary speaker

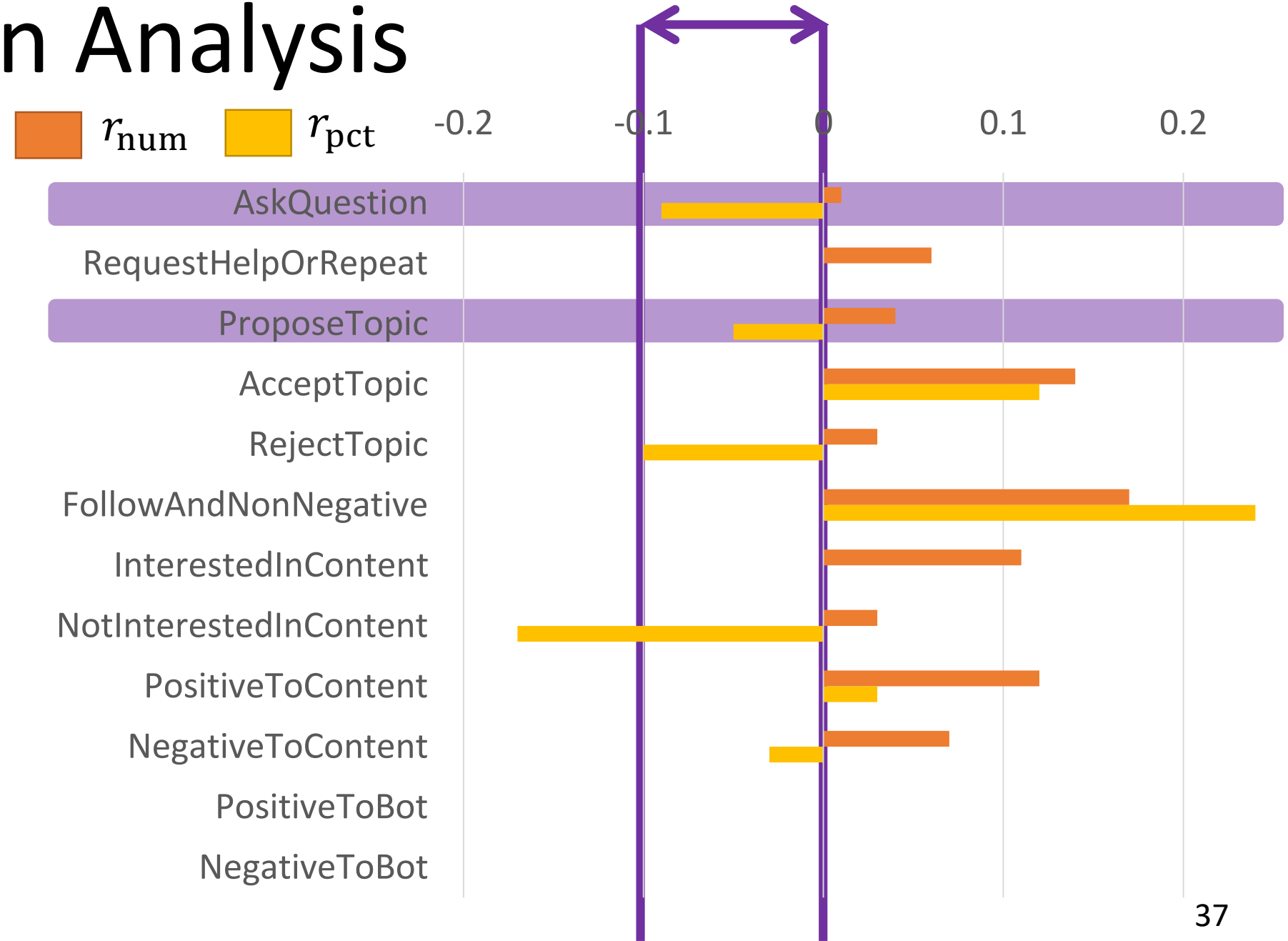
Design, learn, & maintain engaging conversation flows (≠ system-initiative)



# Correlation Analysis

AskQuestion and ProposeTopic slightly impact user ratings in the negative direction

Improve the bot's capability of handling user questions and topic requests

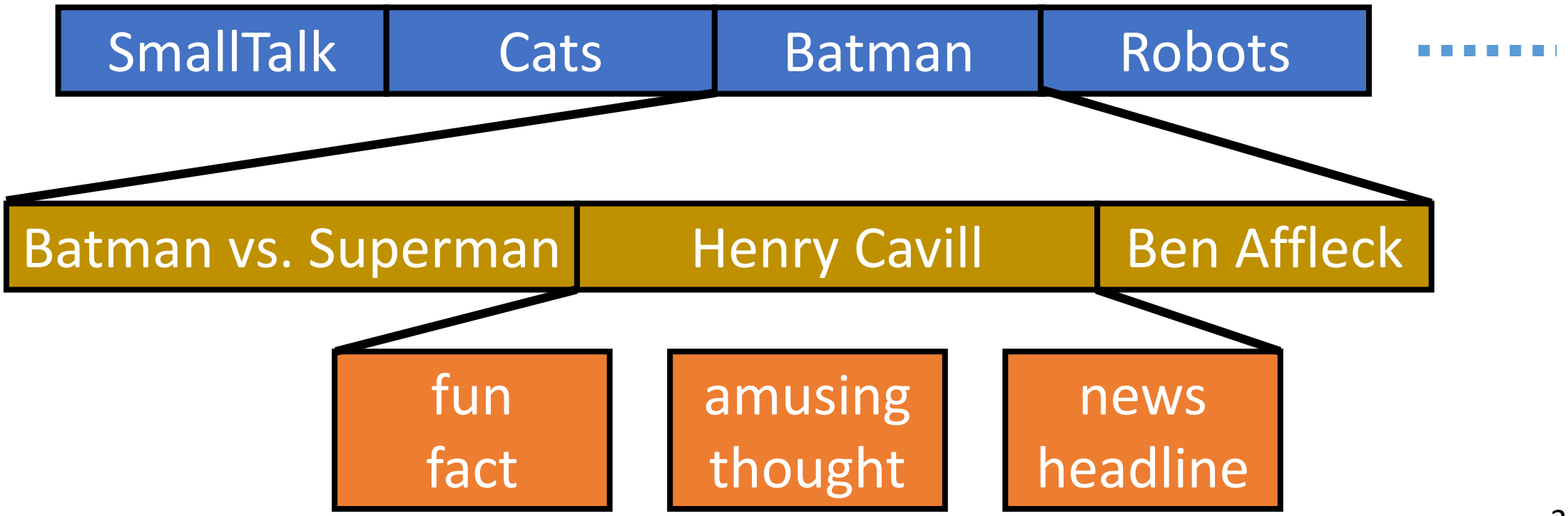


# Limitations

- Conversation ratings and conversation-act-based metrics do not tell
  - which topics are handled badly by the bot
  - which dialog policies need improvement
  - which content sources have less suitable quality
- Segment-level scores can tell us more, but
  - how to segment a socialbot conversation?
  - how to compute a segment-level score?

# Hierarchical Dialog Model

- A conversation is a sequence of topical subdialogs, each of which is a sequence of microsegments, each of which contains posts



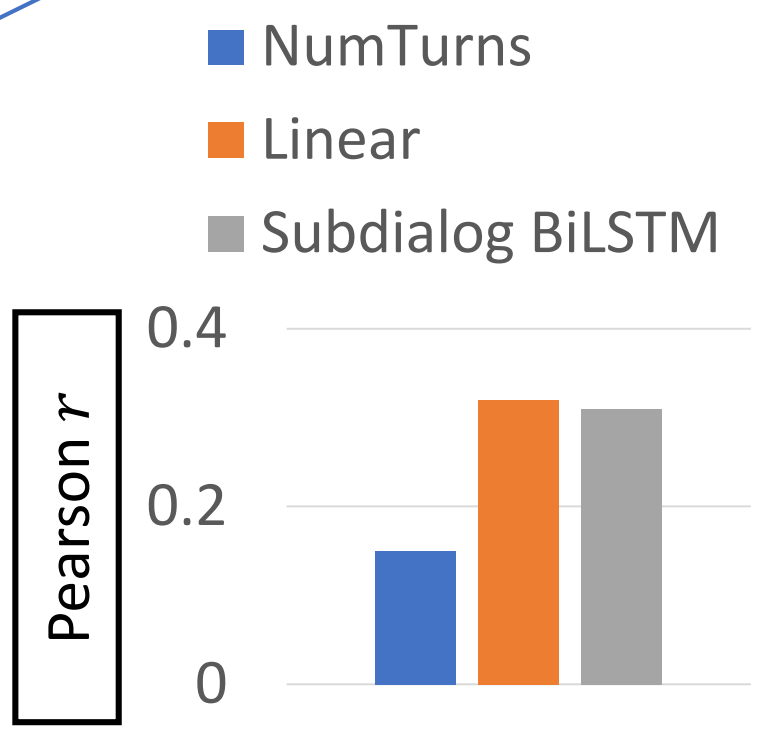
# Automatic Segment Scoring

- Labels: conversation-level user ratings
- Features
  - conversation-act-based metrics
  - other features such as bag-of-words, verbosity, …
- Two different model hypotheses
  - H1: segment scores are predicted just like conversation scores
  - H2: a conversation score is some aggregation of segment scores

# Automatic Segment Scoring

- H1: Linear Scoring Model
  - segment score = $f$(segment features)
  - conversation score = $f$(conversation features)
  - $f(x_1, \ldots, x_d) = \sum_{i=1}^{d} u_i\, x_i + u_0$
- H2: BiLSTM Scoring Model
  - segment score $s_t$ = $h_t$(segment features)
    - $h_1, h_2, \ldots, h_T$: BiLSTM over individual segments
    - $s_{mean} = \text{mean}(s_1, s_2, \ldots, s_T)$, ….
  - conversation score = $g(s_{mean}, s_{max}, s_{min})$
    - $g(s_{mean}, s_{max}, s_{min}) = \sum v_i s_m + v_0$

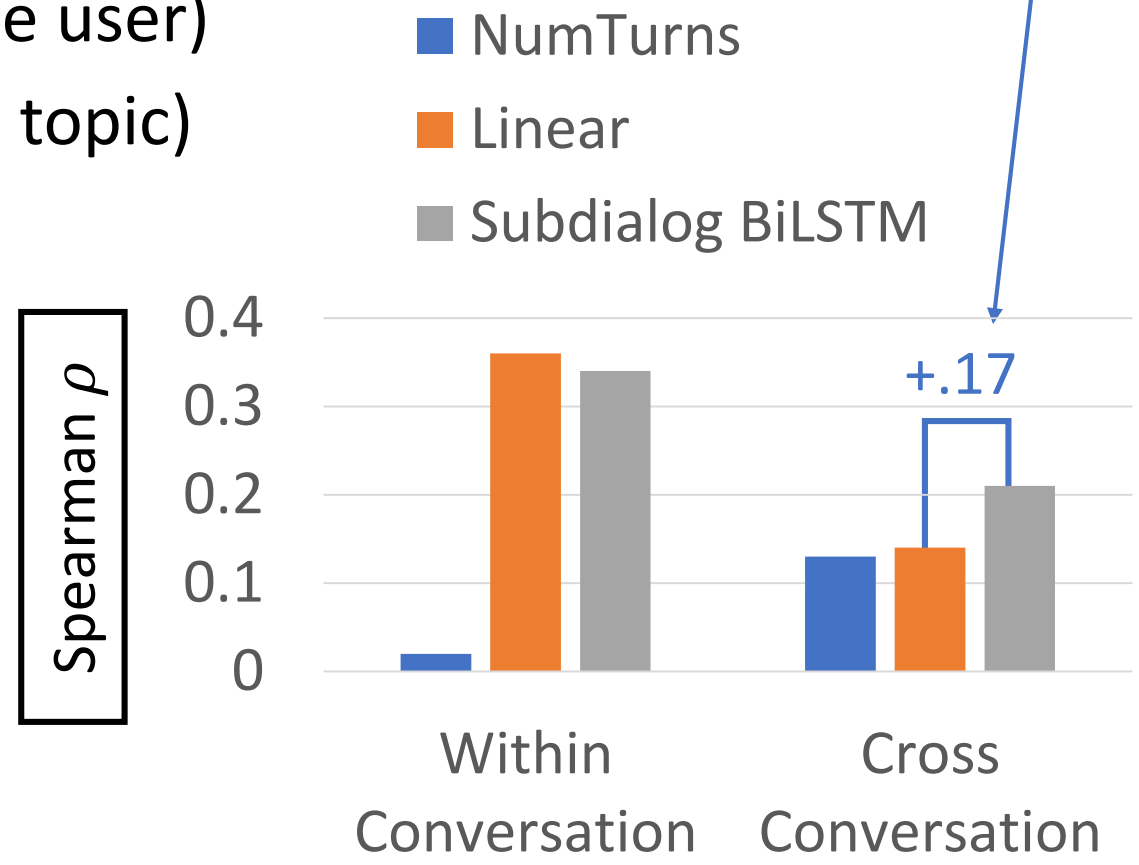
Both learned from conversation-level rating regression



# Evaluation of Subdialog Scores

- Human judgments on subdialog pairs (A, B)
  - 250 within-conversation pairs (same user)
  - 250 cross-conversation pairs (same topic)
  - 5 judgments per pair
- Spearman rank correlation $\rho$ between $x$ and $y$
  - $x$ = votes on A – votes on B
  - $y$ = score of A – score of B

BiLSTM may learn features about the user by using surrounding context



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# Summary: Sounding Board System

- A mixed-initiative and open-domain socialbot
  - user-centric and content-driven dialog strategies
  - it is a new and fast-growing area and we are one of the pioneers
  - several strategies have influenced 2018 socialbots
- System architecture
  - a hierarchical DM framework for efficient dialog control
  - social chat knowledge graph
  - several 2018 socialbots follow a similar DM architecture and acknowledge the importance of content

# Summary: Graph-Based Representation

- Extended conversations grounded on a document
  - a graph-based document representation
  - bridge machine reading and dialog control
- Automatic document representation construction
  - a model for storytelling chain creation
  - an unsupervised dependency-based question generation
  - new NLP tasks that emphasize both dialog context and sentence/question interestingness

# Summary: Multi-Level Evaluation

- In-depth analysis on aspects that influence user ratings
  - conversation acts for socialbot conversations
  - valuable insights for socialbot evaluation
  - better metrics than the conversation length baseline
- Automatic segment scoring for system diagnosis
  - a new hierarchical dialog model for socialbot conversations
  - two scoring models with different hypotheses for segments scores

# Future Directions

- Open-domain and mixed-initiative conversational AI
  - large-scale knowledge base & computational dialog control
  - switch between two roles (primary speaker & active listener)
- Document/content analysis for conversational AI
  - unstructured text to structured representation
  - understand interestingness and socially appropriateness
- Human-in-the-loop for conversational AI
  - data collection & evaluation
  - crowd-powered system

# Acknowledgements


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- Committee Members
  - Leah M. Ceccarelli, Yejin Choi, Hannaneh Hajishirzi, Eve Riskin, Geoffrey Zweig
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# Thank You