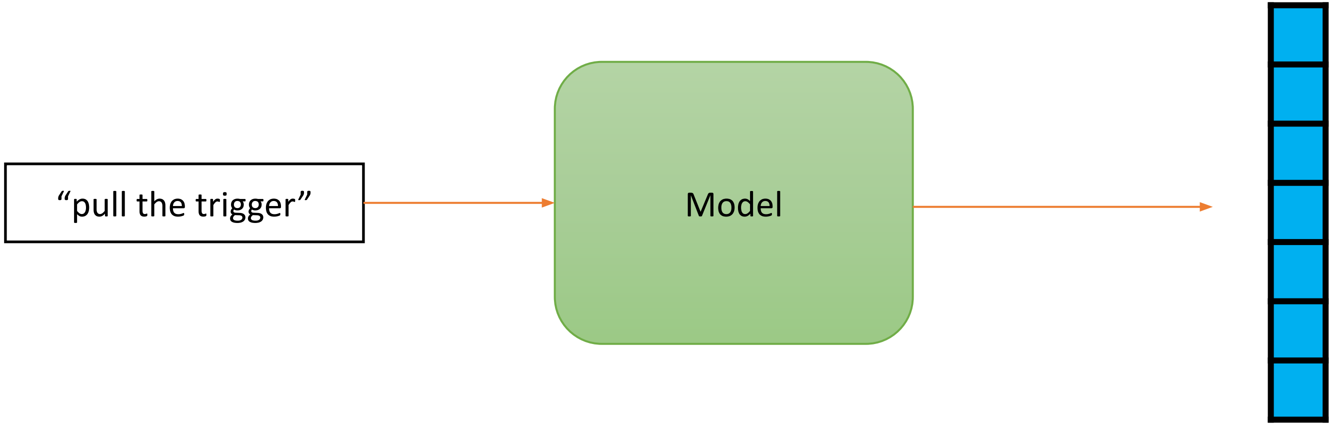
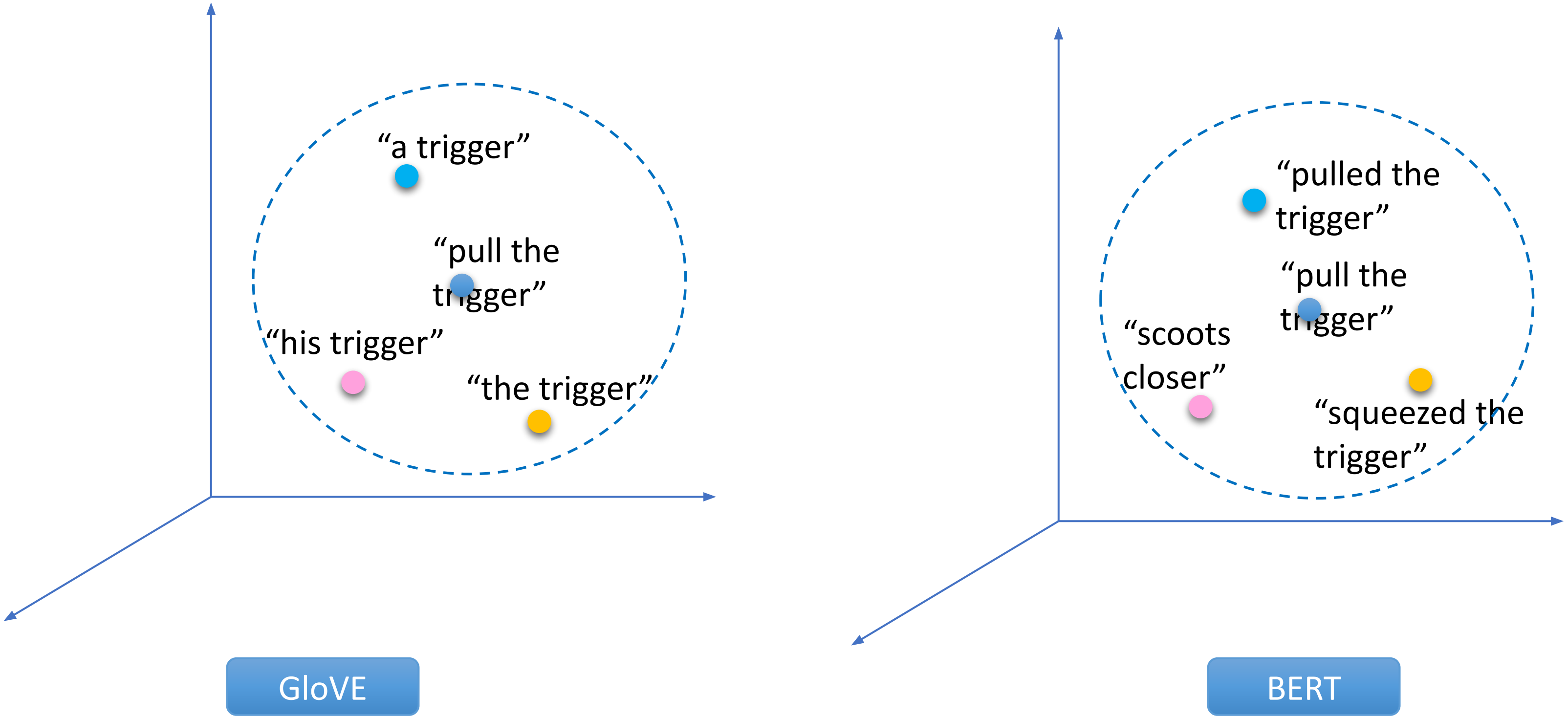
Phrase-BERT:
Improved Phrase Embeddings from BERT with an Application to Corpus Exploration

Shufan Wang Laure Thompson Mohit Iyyer

A general-purpose phrase embedding



Phrase Nearest Neighbours



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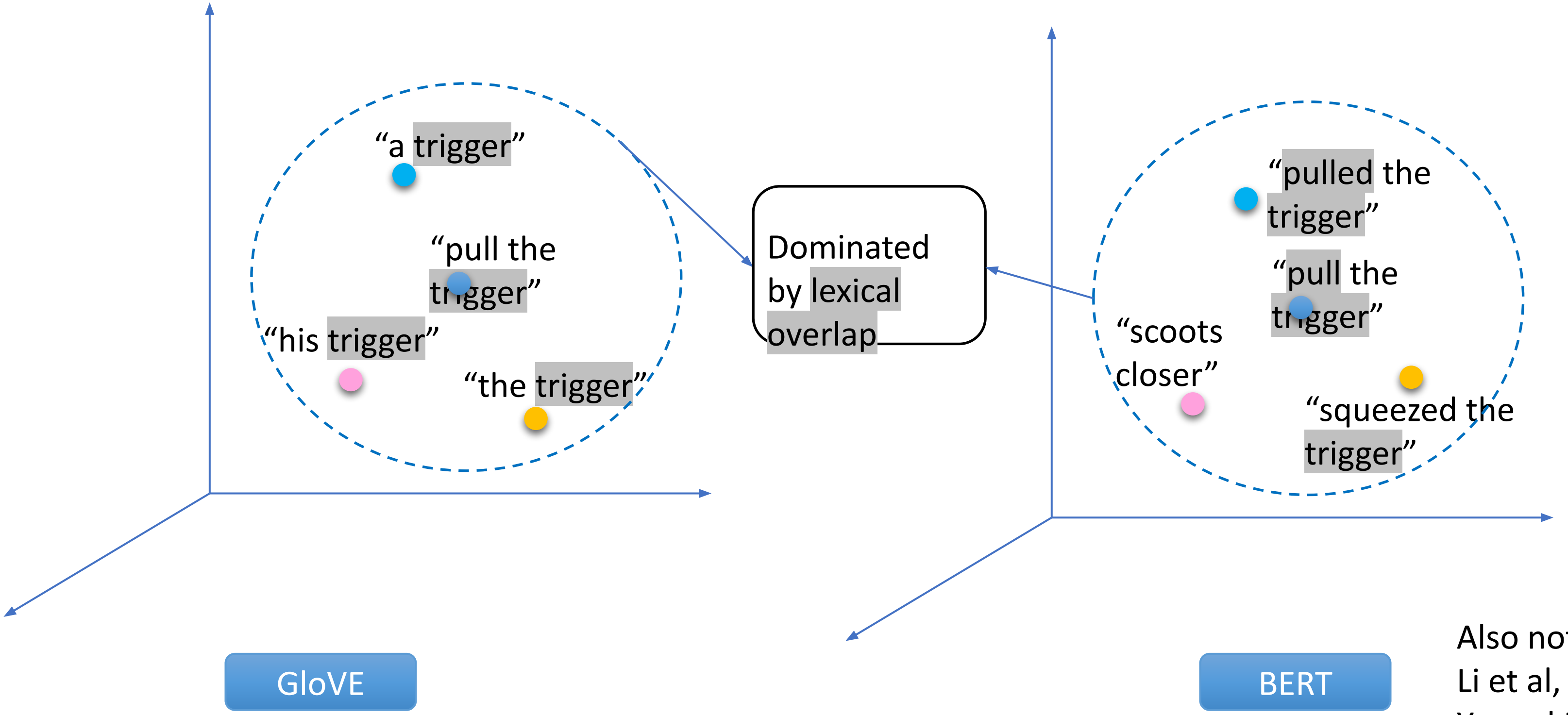

Also noted by:
Li et al, EMNLP 2020;
Yu and Ettinger, ACL 2020

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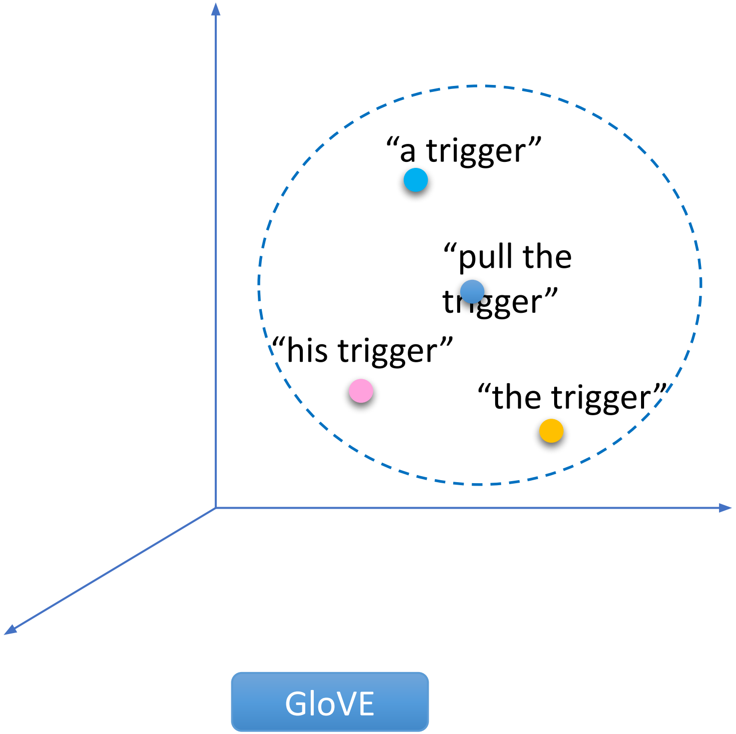

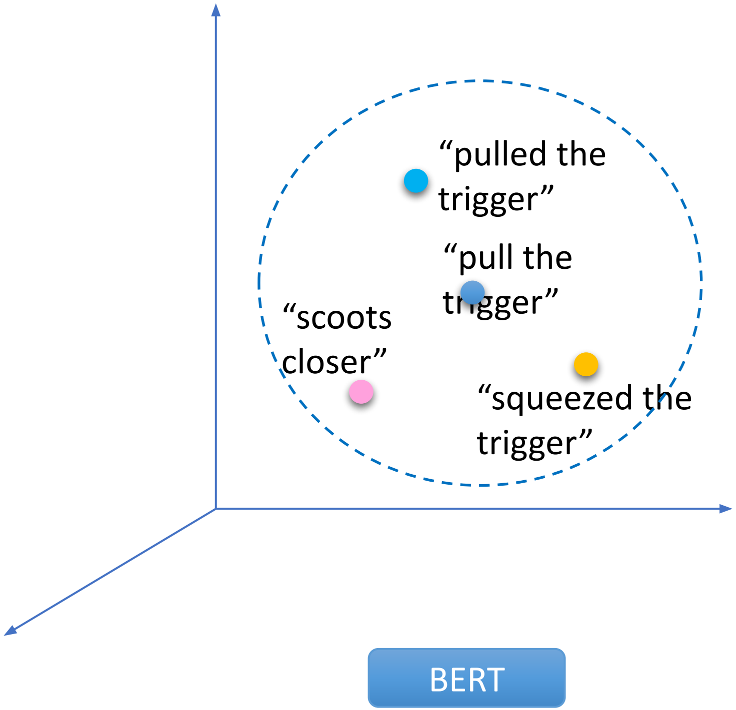

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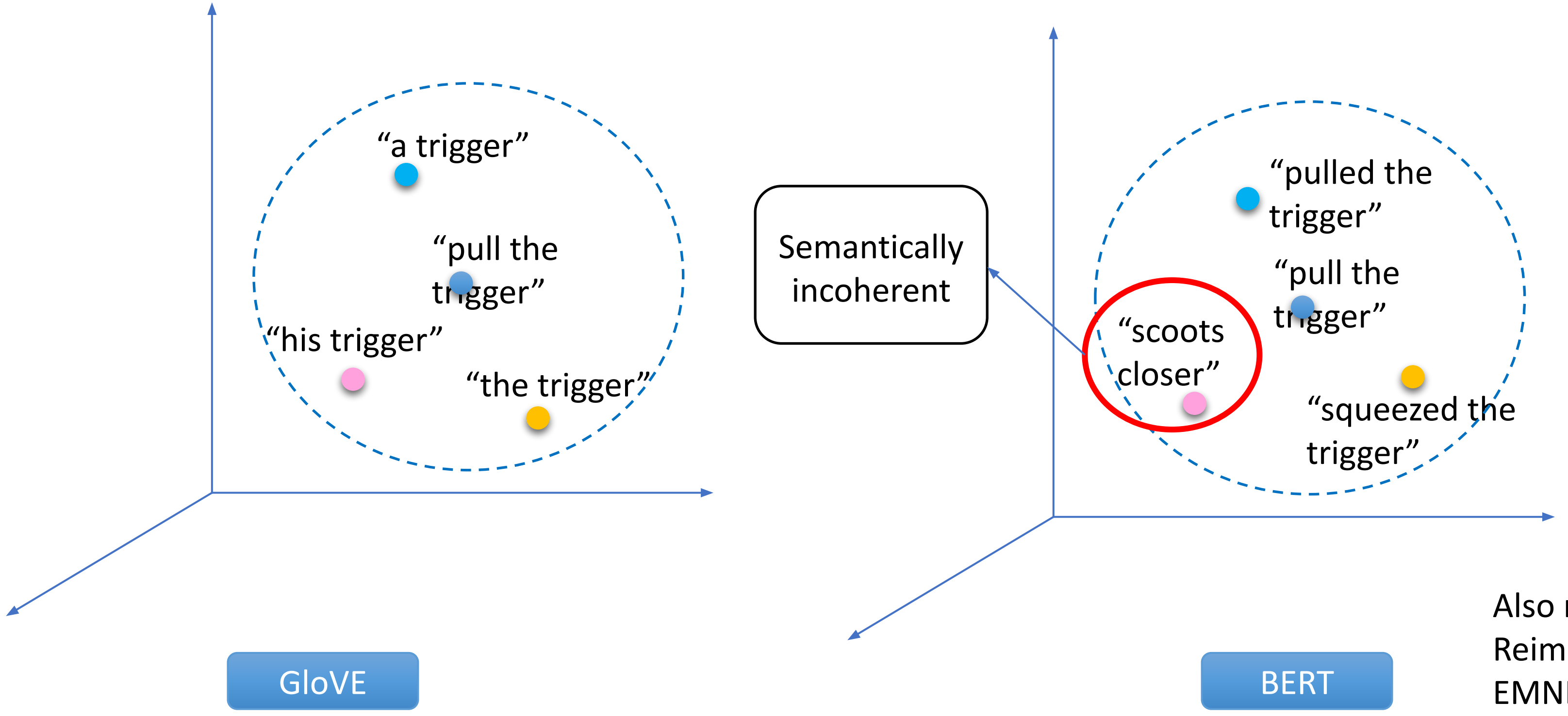

Also noted by:
Reimers and Gurevych, EMNLP 2019;
Yu and Ettinger , ACL 2020

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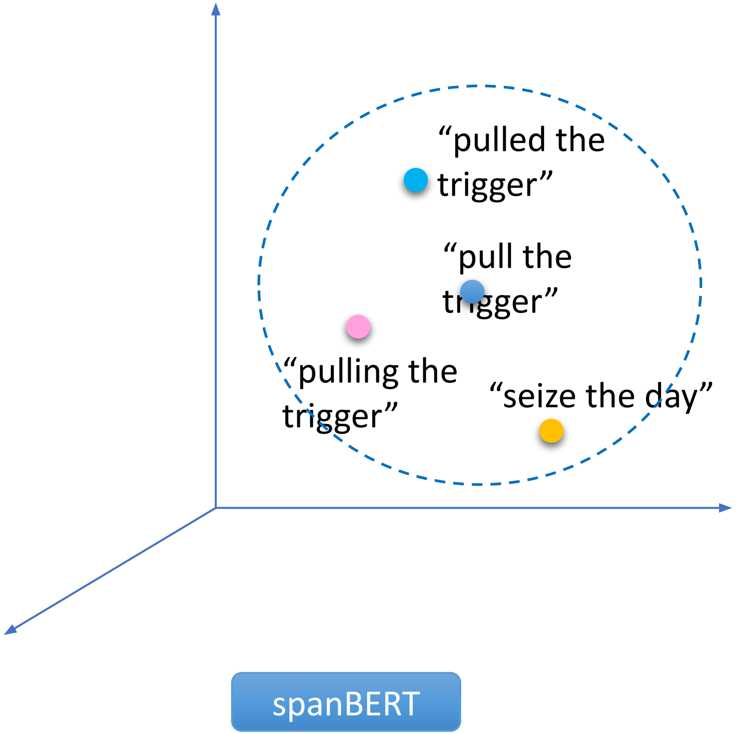

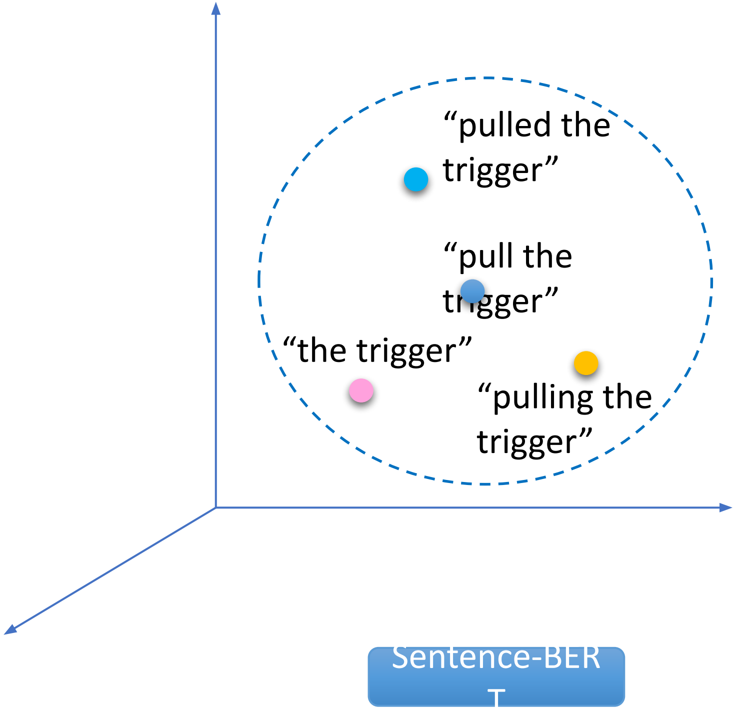

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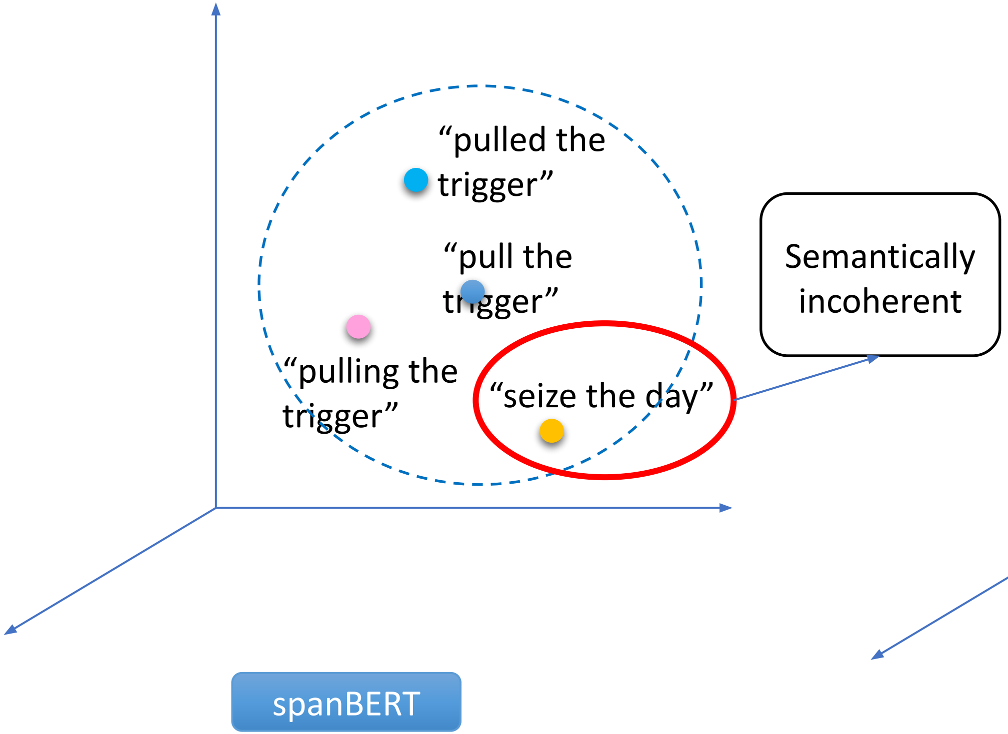

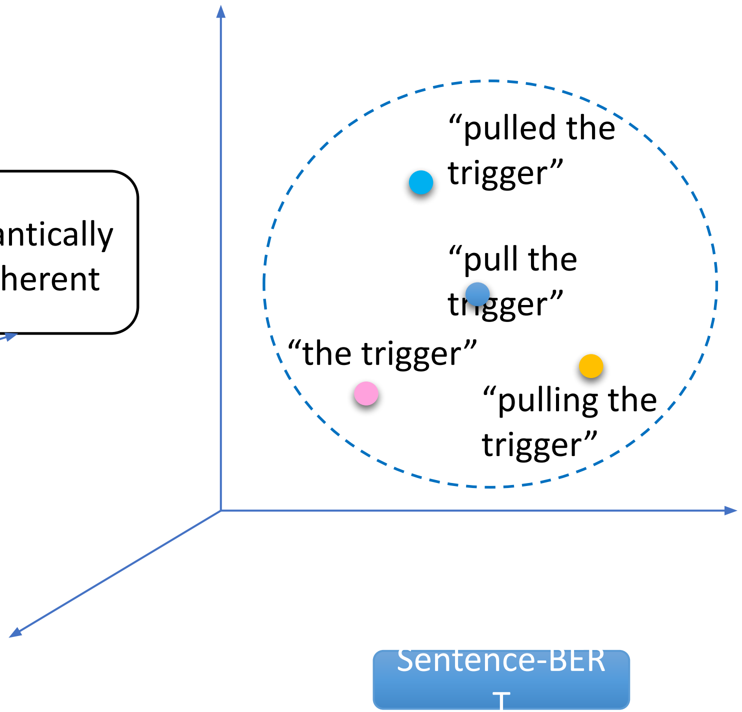

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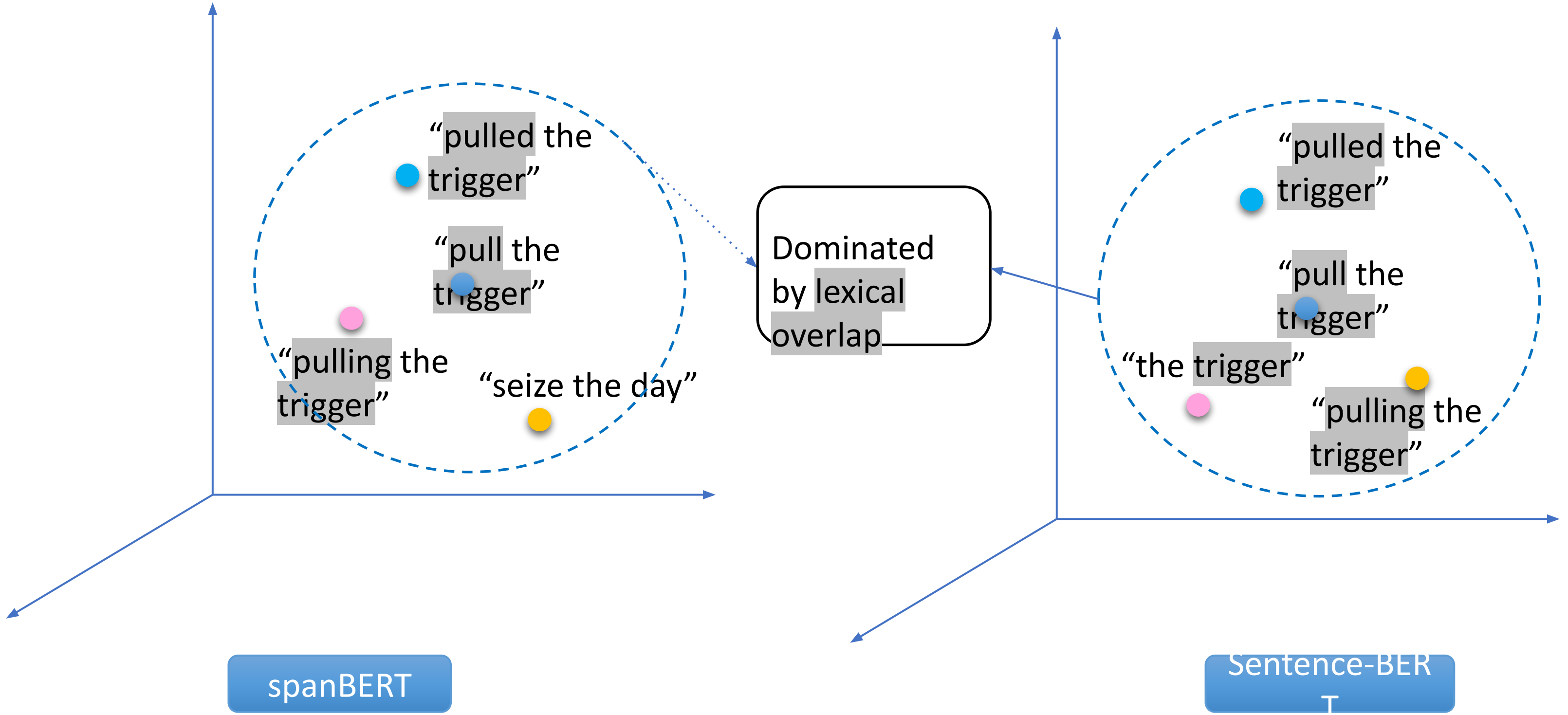
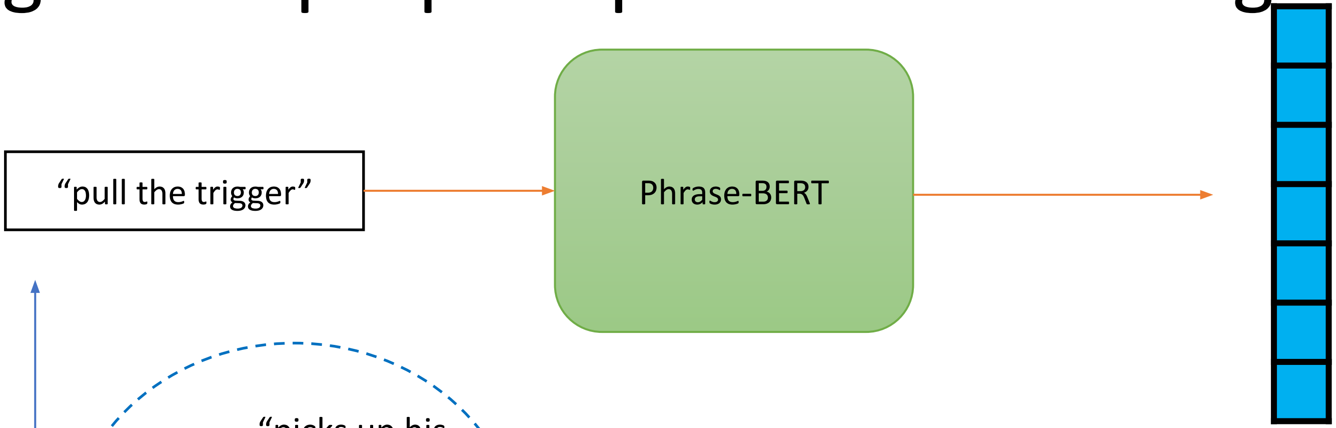
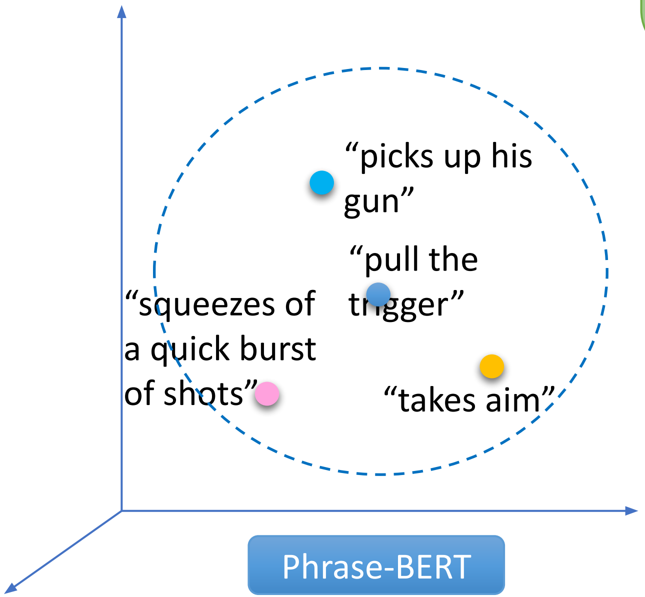


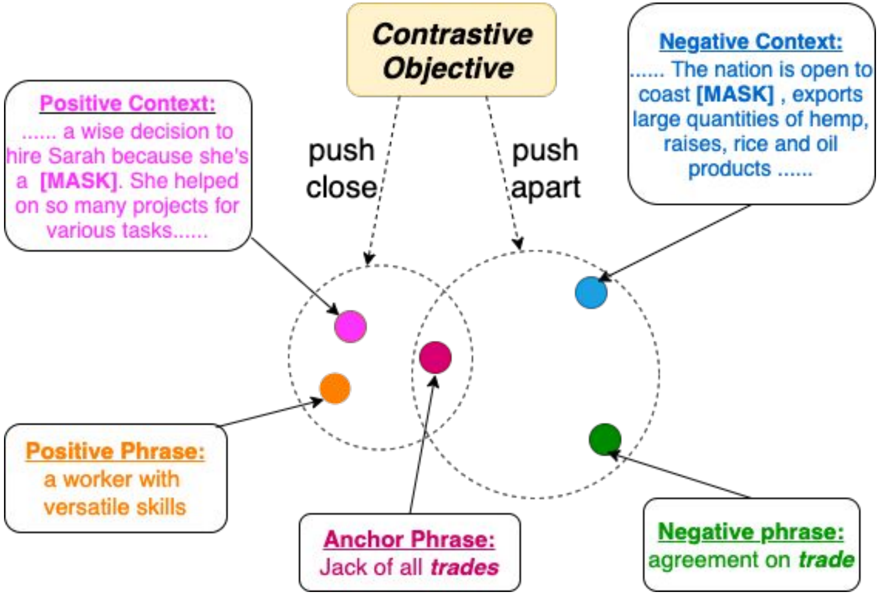
A general-purpose phrase embedding



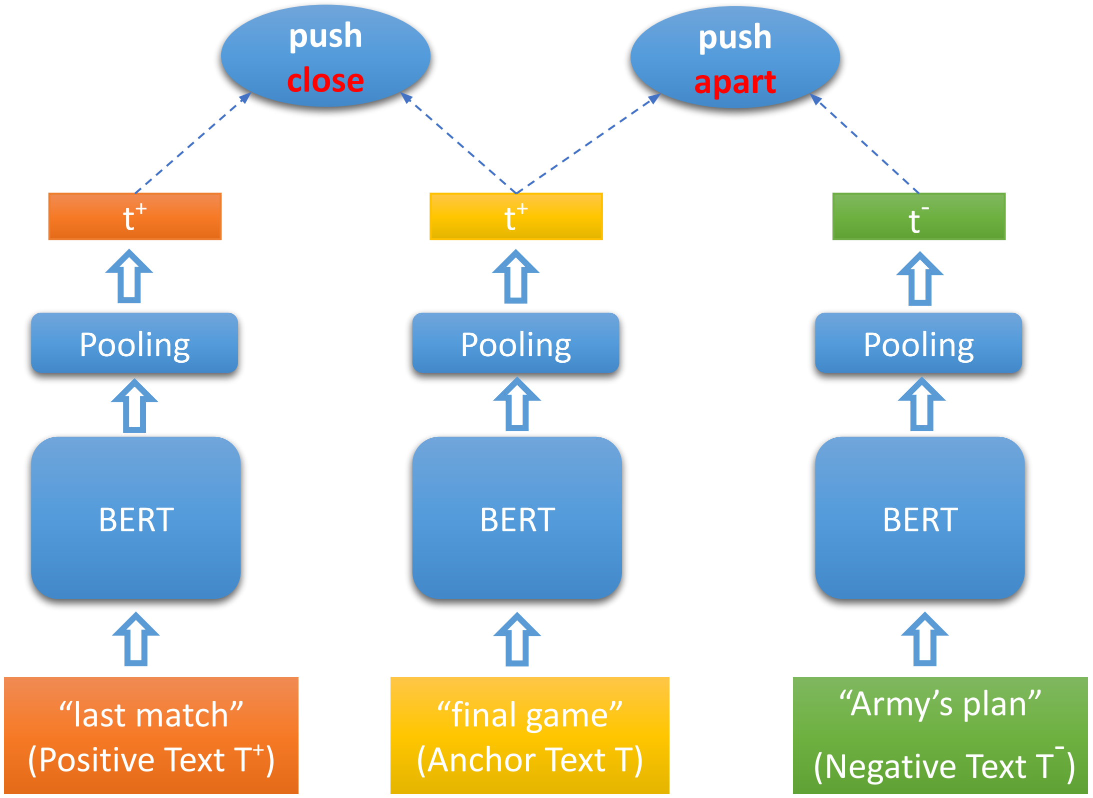


- Meaningful phrase representation
- Lexical diversity in embedding space
- Easily integrated with a phrase-based topic model

A Contrastive Learning approach

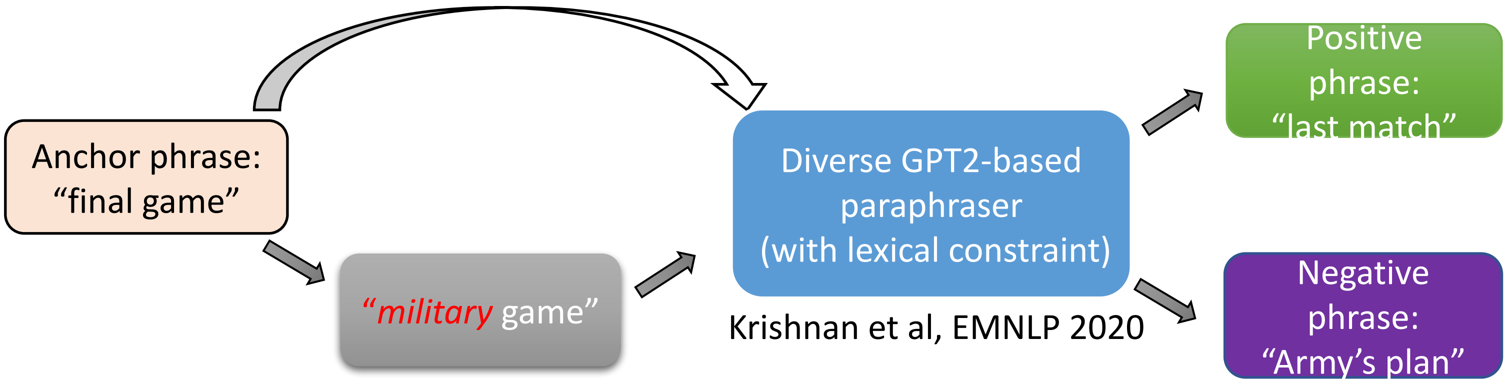


A Triplet Loss Objective



A dataset of diverse paraphrases

- Construct diverse paraphrases to remove lexical cues:



A dataset of phrase-in-context

- Context are from Books 3 Corpus (a large scale 100 GB collection of books from various genres)

Positive Context:
…… The current **legal education** consists of a 5-year-long course after which the scholar is granted a bachelor's degree ……

Anchor phrase: "Legal education"

- Negative contexts are randomly sampled
- Mask off the actual occurrence of the anchor phrase

Phrase Semantics Evaluation

A diverse set of phrase-level evaluation tasks

- Turney: unigram-bigram concept match
- BiRD: bi-gram Relatedness
- PPDB: paraphrase detection
- PPDB-filtered: paraphrase detection
- PAWS-short: paraphrase detection

A diverse set of phrase-level evaluation tasks

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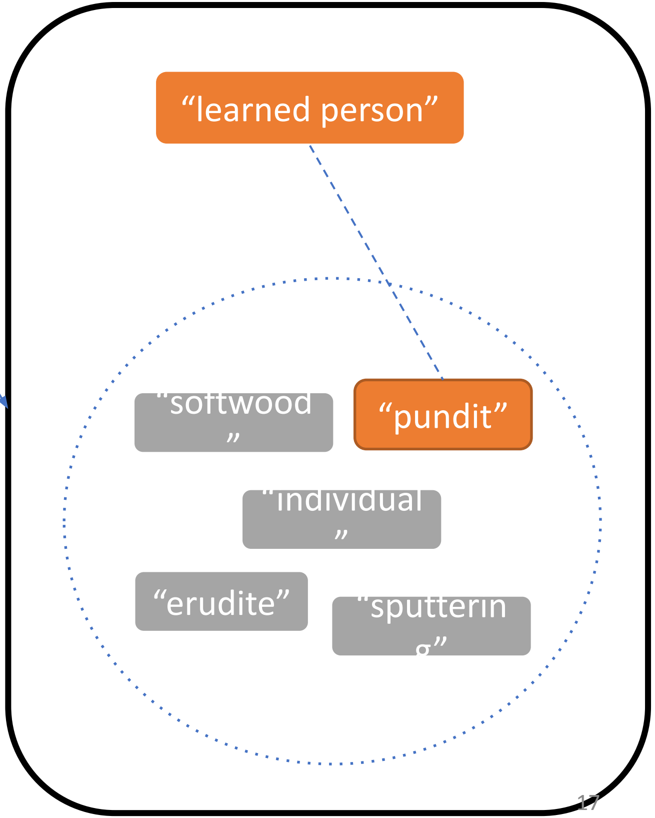

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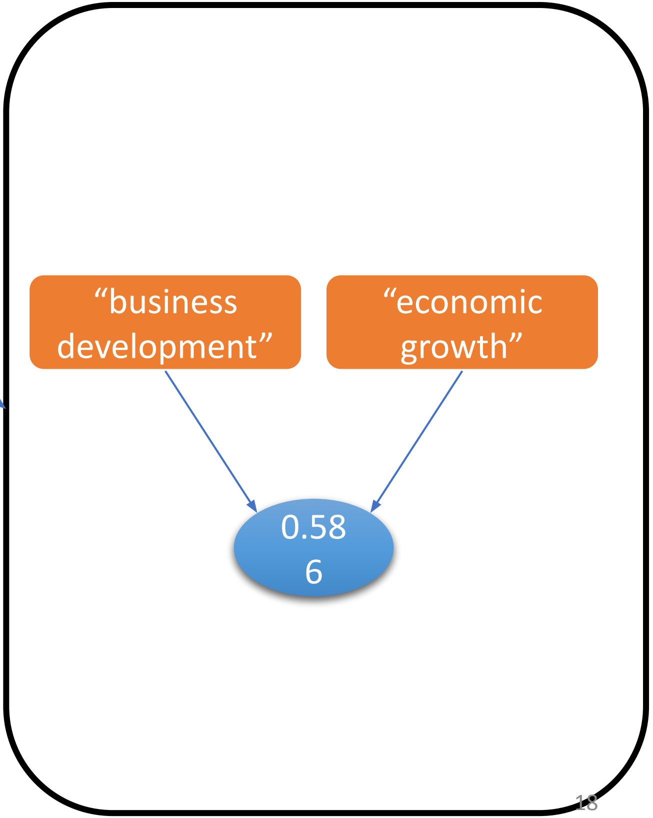

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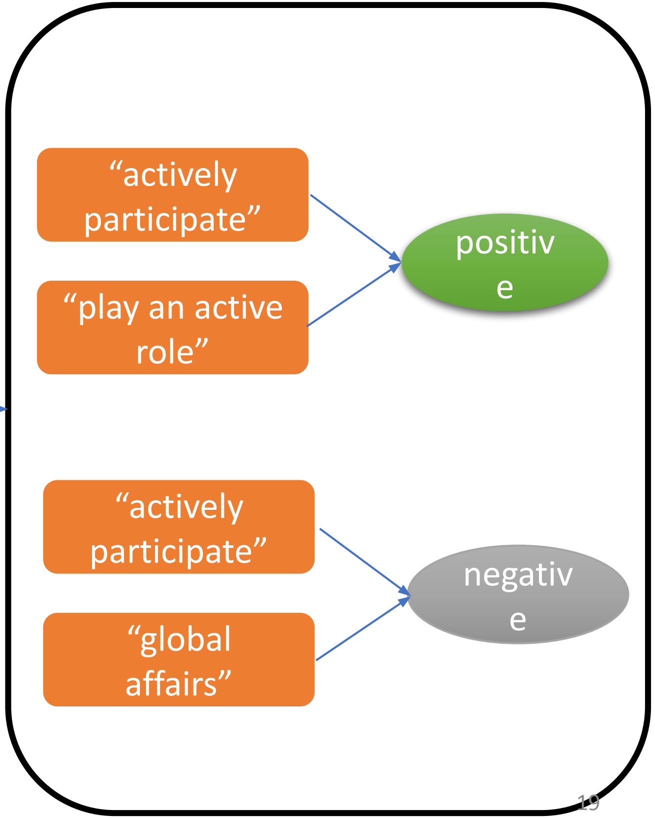

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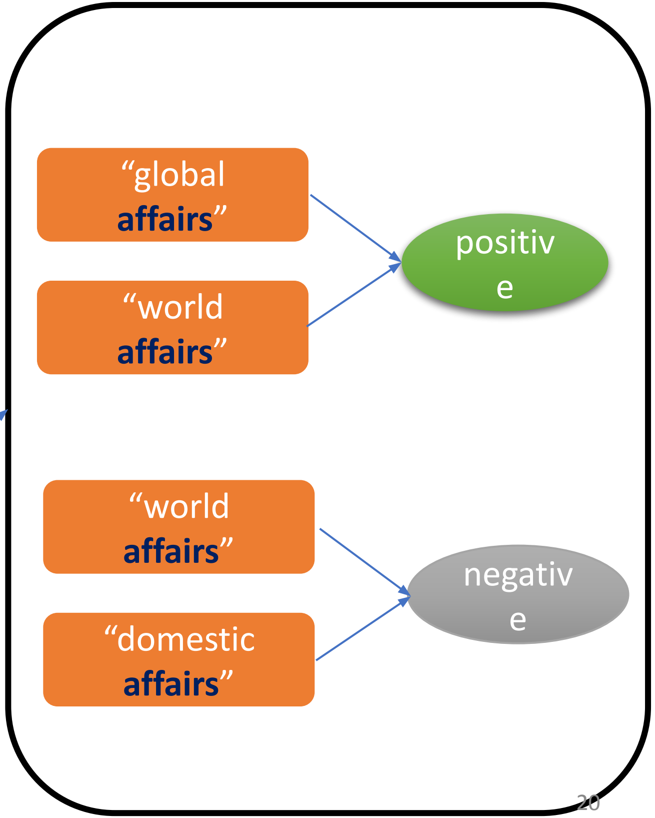

* Yu and Ettinger, ACL 2020

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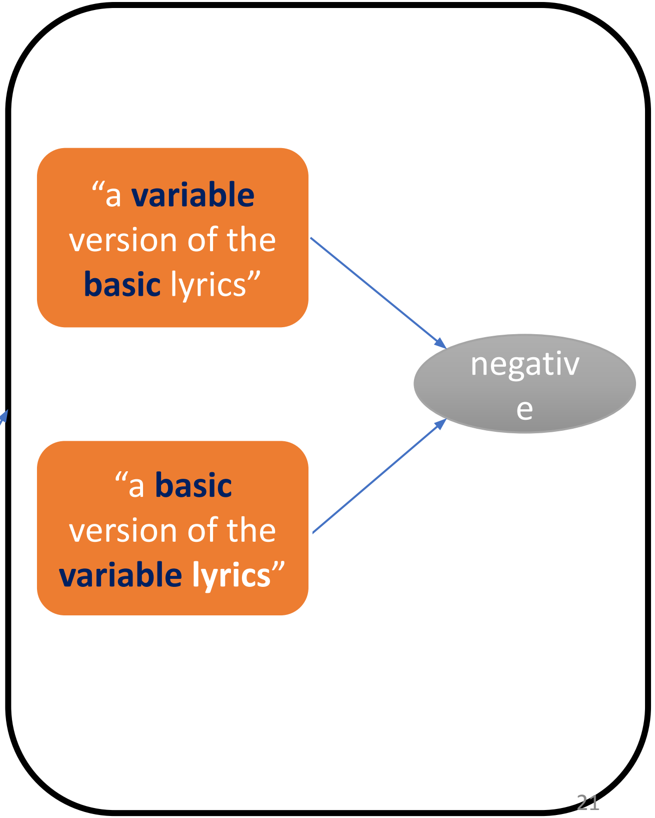

Phrases semantics evaluation

Model	Turney	BiRD	PPDB-filtered	PPDB	PAWS-short
Glove	37.8	0.560	44.2	47.2	50.0
BERT	42.6	0.444	60.1	86.2	50.0
SpanBERT	38.7	0.258	57.3	95.1	50.1
Sentence-BERT	51.8	0.687	64.2	95.8	50.0
Phrase-BERT	**57.2**	**0.688**	**68.0**	**97.6**	**58.9**

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Phrase-BERT consistently outperforms baselines across all tasks

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BERT sometimes underperforms un-contextualized baselines

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SpanBERT is not the solution for phrases representation

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Sentence-BERT (contrastively fine-tuned) offers closer performance to Phrase-BERT

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BERT-based baselines are great at taking lexical cues

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But over-reliance on lexical overlaps hurts phrase semantics understanding

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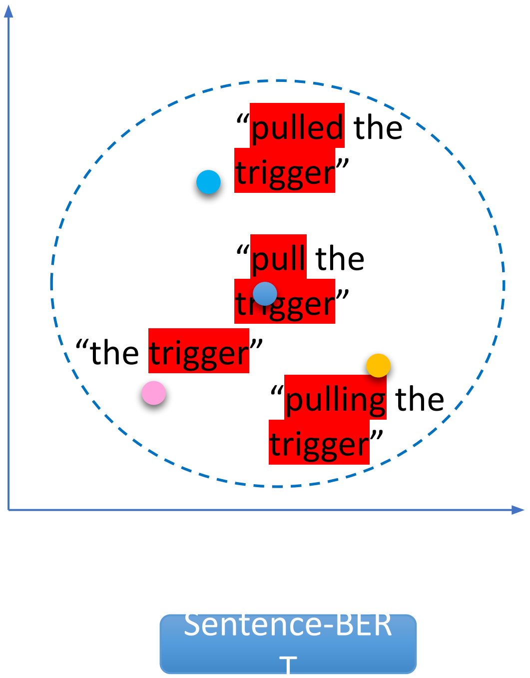
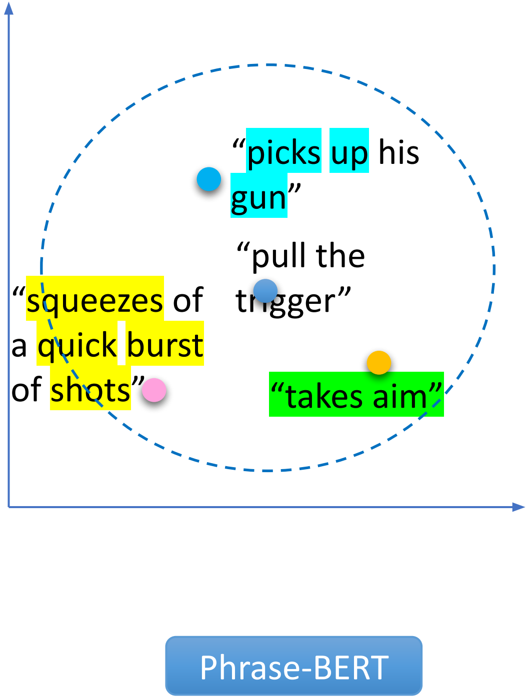
Compositionality is hard to capture for all models

Lexical diversity





Lexical diversity

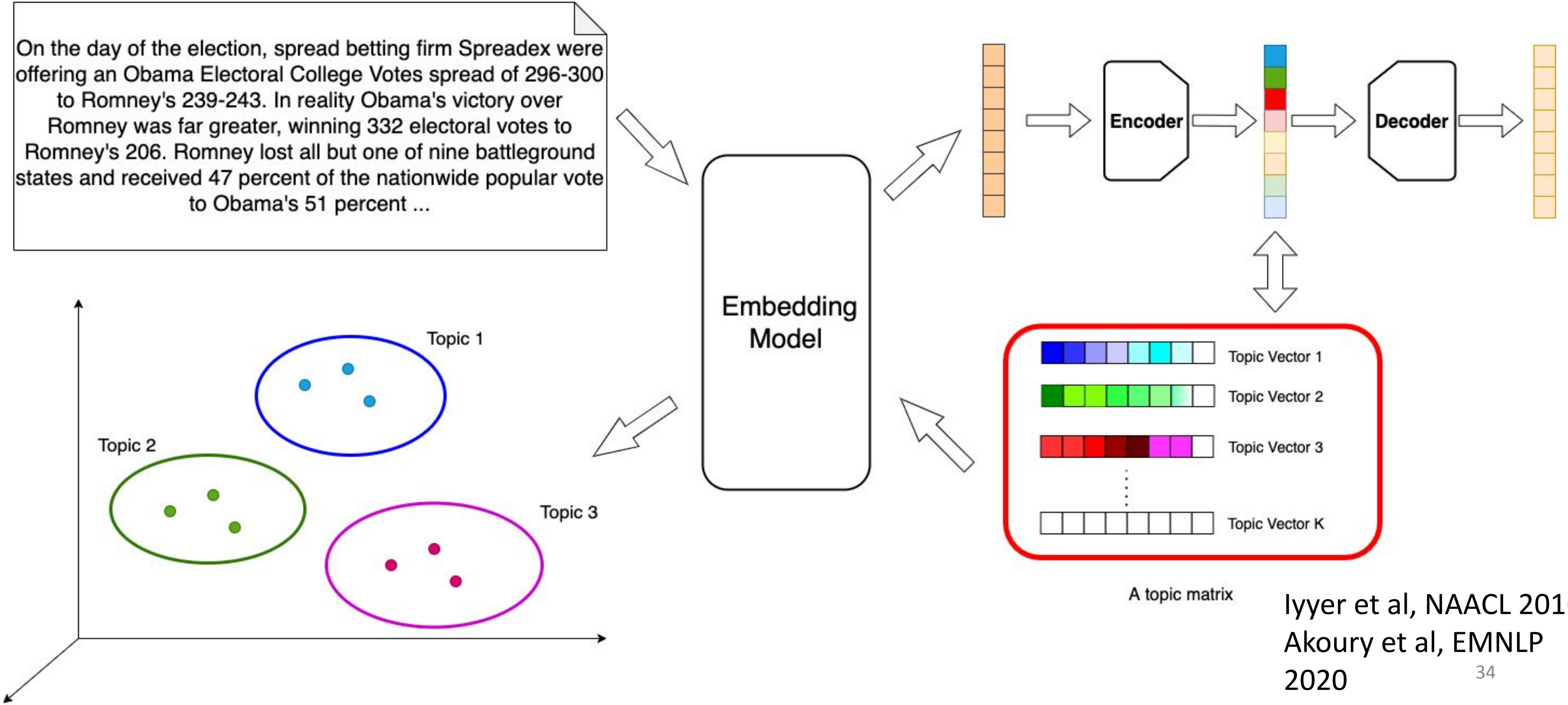
Model	percentage of new tokens (↑= more diverse)	LCS-Precision (↓= more diverse)	Levenshtein distance (↑= more diverse)
Sentence-BERT	5.0	51.1	8.5
Phrase-BERT	**5.3**	**47.6**	**8.7**

Phrase-based topic model: a case study

Baseline model: LDA

- LDA = latent dirichlet allocation
- The dominant approach for corpus exploration
- Each topic is represented by a list of unigrams.

Autoencoder + phrase-BERT = Phrase-based topic model



Iyyer et al, NAACL 2016
Akoury et al, EMNLP 2020

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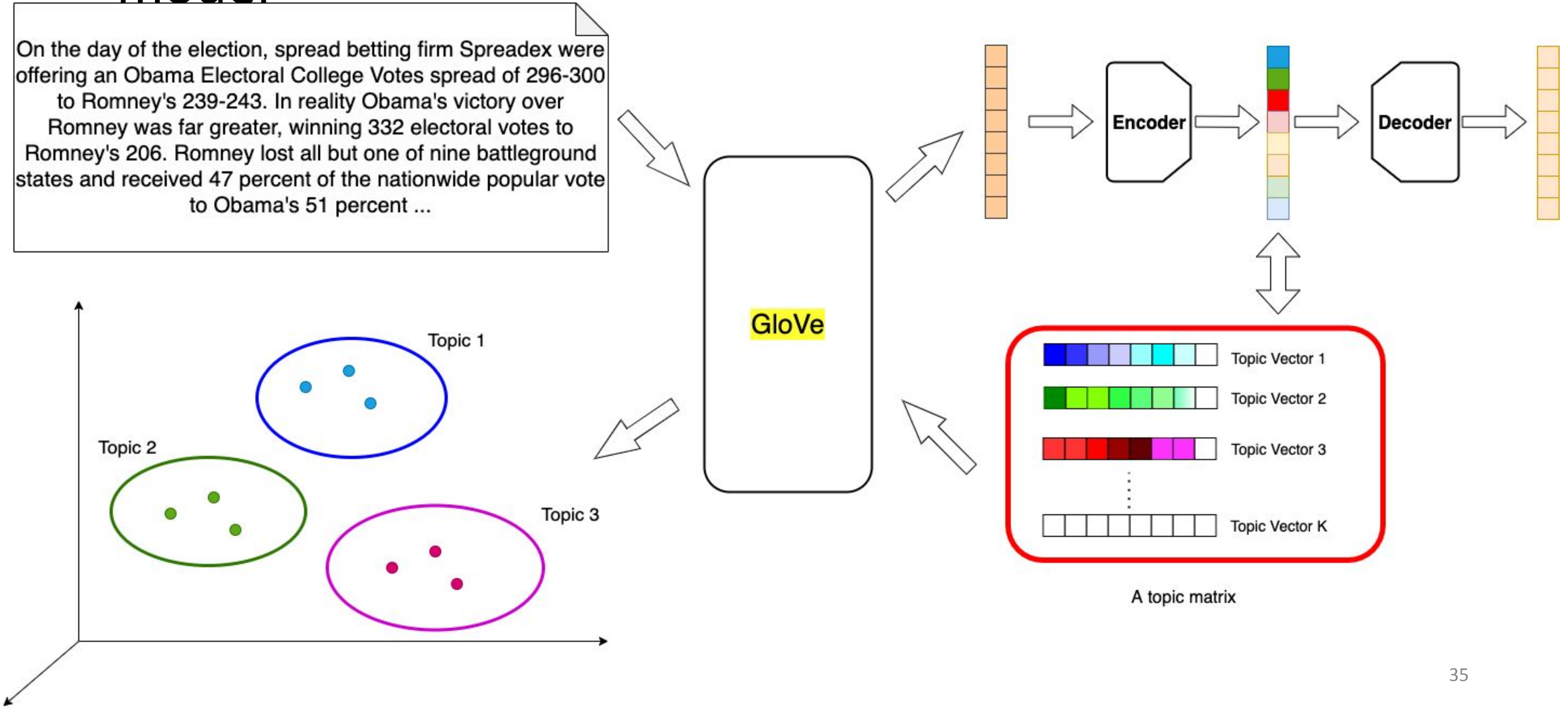

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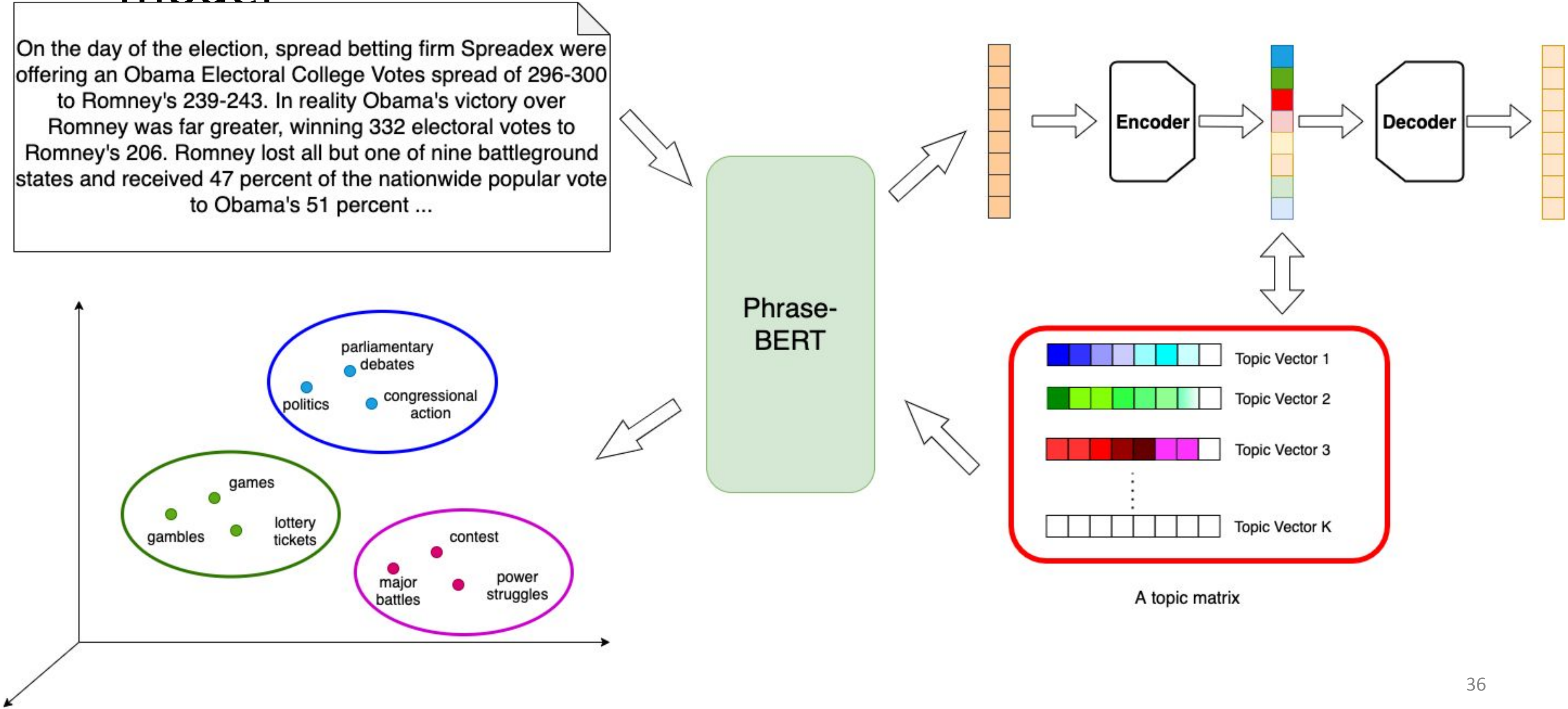

Human Evaluation on Topic Coherence

Model	Wiki	Story	Reviews	Average
Phrase-BERT based topic model (**PNTM**)	**83.3**	**76.7**	**77.3**	**79.1**
Phrase-LDA (**pLDA**)	55.3	48.7	50.7	51.6
Topical N-Gram (**TNG**)	37.3	58.7	60.0	52.1
Unigram (GloVe) based topic model (**UNTM**)	76.9	70.0	62.0	69.6
Latent Dirichlet Allocation (**LDA**)	48.7	48.0	52.7	49.8

Word Intrusion Test for Topic Coherence
(↑= more coherent)

Human Evaluation on Topic-to-document relatedness

Model	**Accuracy**
Phrase-BERT based topic model (**PNTM**)	**89.3**
Phrase-LDA (**pLDA**)	89.3
Topical N-Gram (**TNG**)	78.7
Unigram (GloVe) based topic model (**UNTM**)	80.7
Latent Dirichlet Allocation (**LDA**)	90.0

Topic Intrusion Test for Topic Assignment (↑= more agreement with humans in assigning topics to documents)

Phrase-BERT enables meaningful topic by reducing lexical overlap

Topic on "sports"

winning, semifinalist, finisher, a race, raceme, race, the race, the race's, side rowing competition, formula one

the semifinal, Olympic, marathon, raceme, bicyclist, semifinalist, side rowing race, race, place finish, side rowing competition

Topic on "music"

the Beatles, his album, the album, discography, the album, an album, Beatles, this album, the Beatles', their album

musician, his music, musical, concerto, chorale, liver performance, a concert, accompaniment, pianistic, antiphonal

BERT

Phrase-BERT

Conclusion and Future work

- Our contributions:
  - Phrase-BERT, a more powerful phrase embedding models
  - ↑ capture phrase semantics, ↓ lexical overlap
  - Easily integrated into a phrase-based topic model

- Future directions:
  - Towards a benchmark of holistic phrase-evaluation
  - Multi-lingual phrase embeddings,
  - Other downstream tasks involving phrases

Thank you!