The Third Workshop on Evaluating Vector Space Representations for NLP

Anna Rogers, Aleksandr Drozd, Anna Rumshisky, Yoav Goldberg

June 6, 2019

Co-located with NAACL 2019, Minneapolis, USA

RepEval 2016 @ACL

- Organizers
  - Omer Levy
  - Felix Hill
  - Anna Korhonen
  - Kyunghyun Cho
  - Roi Reichart
  - Yoav Goldberg
  - Antoine Bordes
- analysis track + proposal track
- 39 submissions, 16 accepted (5 in the analysis track, 41% acceptance)
- $\approx$ 150 attendees

RepEval 2017 @EMNLP

- Organizers
  - Sam Bowman
  - Yoav Goldberg
  - Felix Hill
  - Angeliki Lazaridou
  - Omer Levy
  - Roi Reichart
  - Anders Søgaard
- proposal track, MultiNLI shared task (to evolve into GLUE)
- 16 submissions, 11 accepted (68.8% acceptance)
- $\approx$ 250 attendees

Do we even need word embeddings anymore?

RepEval 2019 @ NAACL

- Organizers
  - Anna Rogers
  - Aleksandr Drozd
  - Anna Rumshisky
  - Yoav Goldberg
- analysis track + proposal track
- 25 submissions (+ 2 withdrawn), 13 accepted (52% acceptance)

RepEval 2019: Program Committee

- Omri Abend
- Emily Bender
- Sam Bowman
- Jose Camacho Collados
- Alexis Conneau
- Barry Devereux
- Georgiana Dinu
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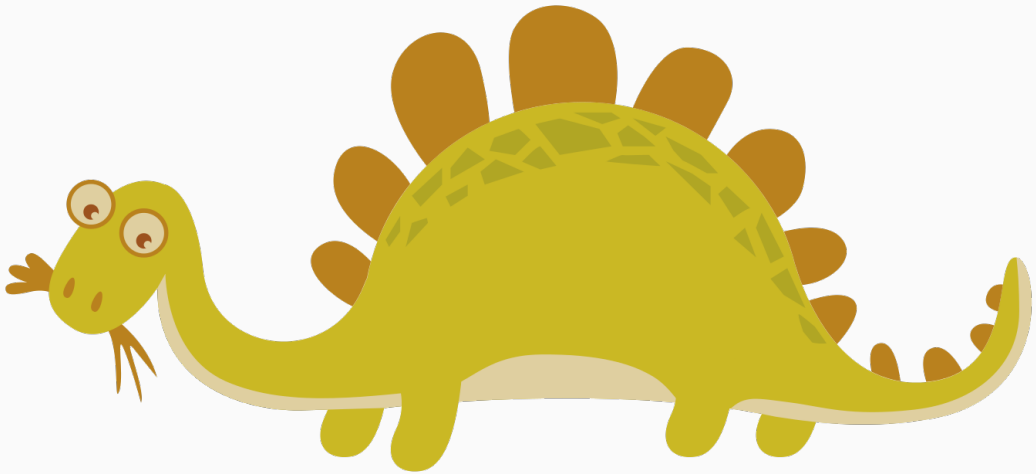
- Diarmuid O'Seaghdha
- Gabriel Stanovsky
- Karl Stratos
- Yulia Tsvetkov
- Ivan Vulić
- Luke Zettlemoyer

Vector Meaning Representations: 6 Years Later

A brief and biased overview

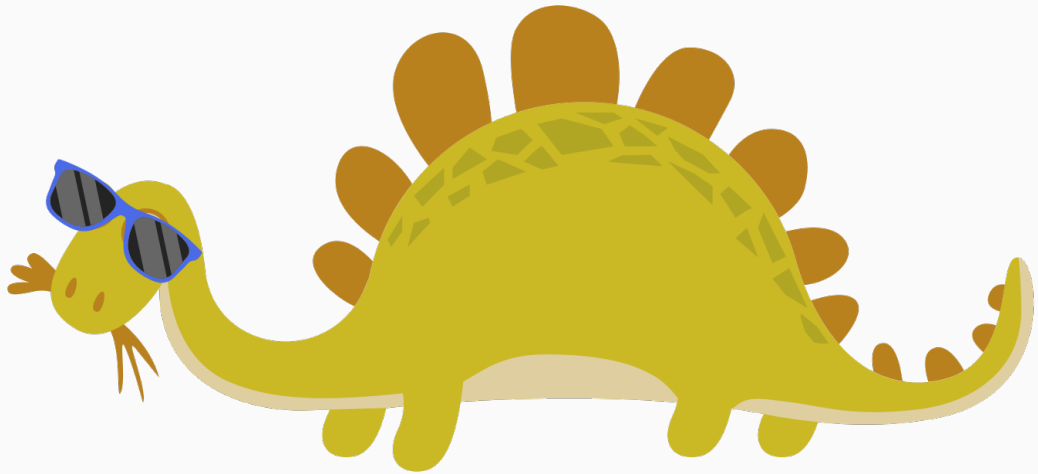
When the earth was still flat...

- distributional hypothesis (Firth, 1957; Harris, 1954) $\Rightarrow$ corpus linguistics work on word association measures;
- count-based distributional meaning representations, sparse and with reduced dimensionality with PCA, PPMI, SVD...
- sem. spaces in psycholinguistics: LSA (Landauer et al., 1998), HAL (Lund and Burgess, 1996), ICA (Väyrynen and Honkela, 2004)...
- work on DSM compositionality (Mitchell and Lapata, 2008, 2010; Baroni and Zamparelli, 2010; Baroni, 2013; Lazaridou et al., 2013)

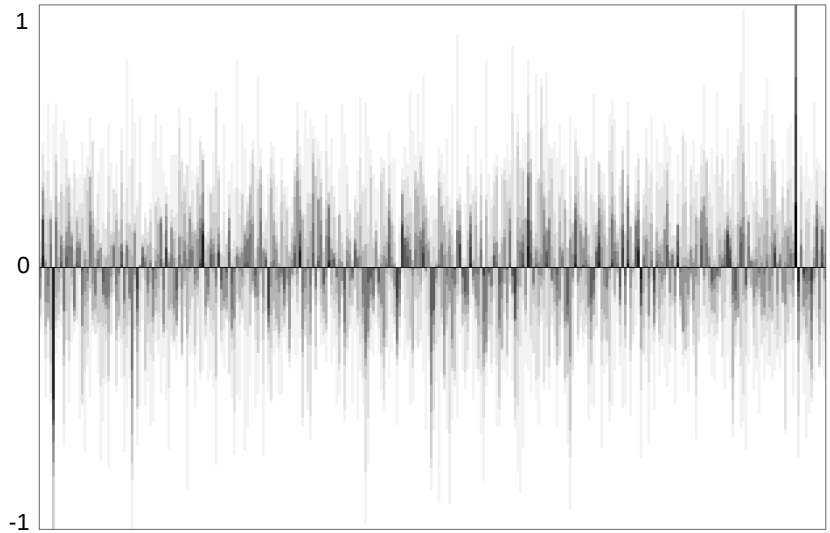


And then deep learning came

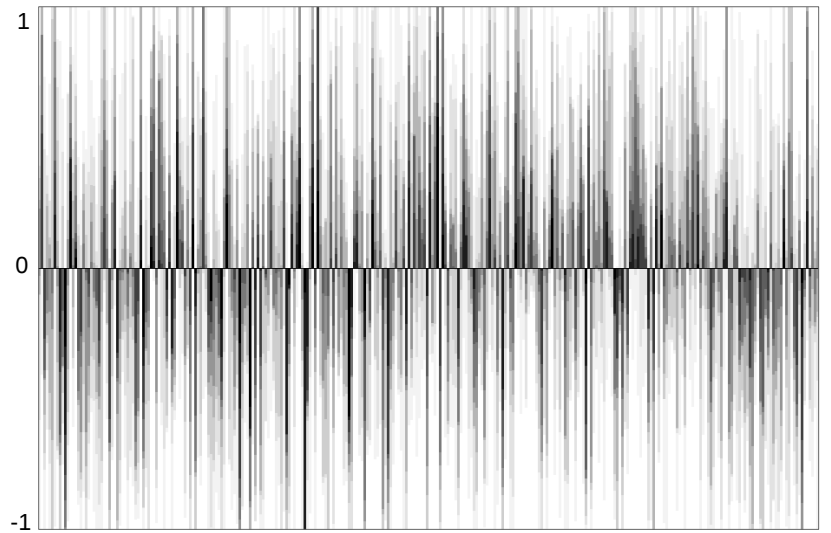
- word2vec (Mikolov et al., 2013a,b)
- Don't count, predict! (Baroni et al., 2014)
- GloVe (Pennington et al., 2014)



Something meaningful is going on!



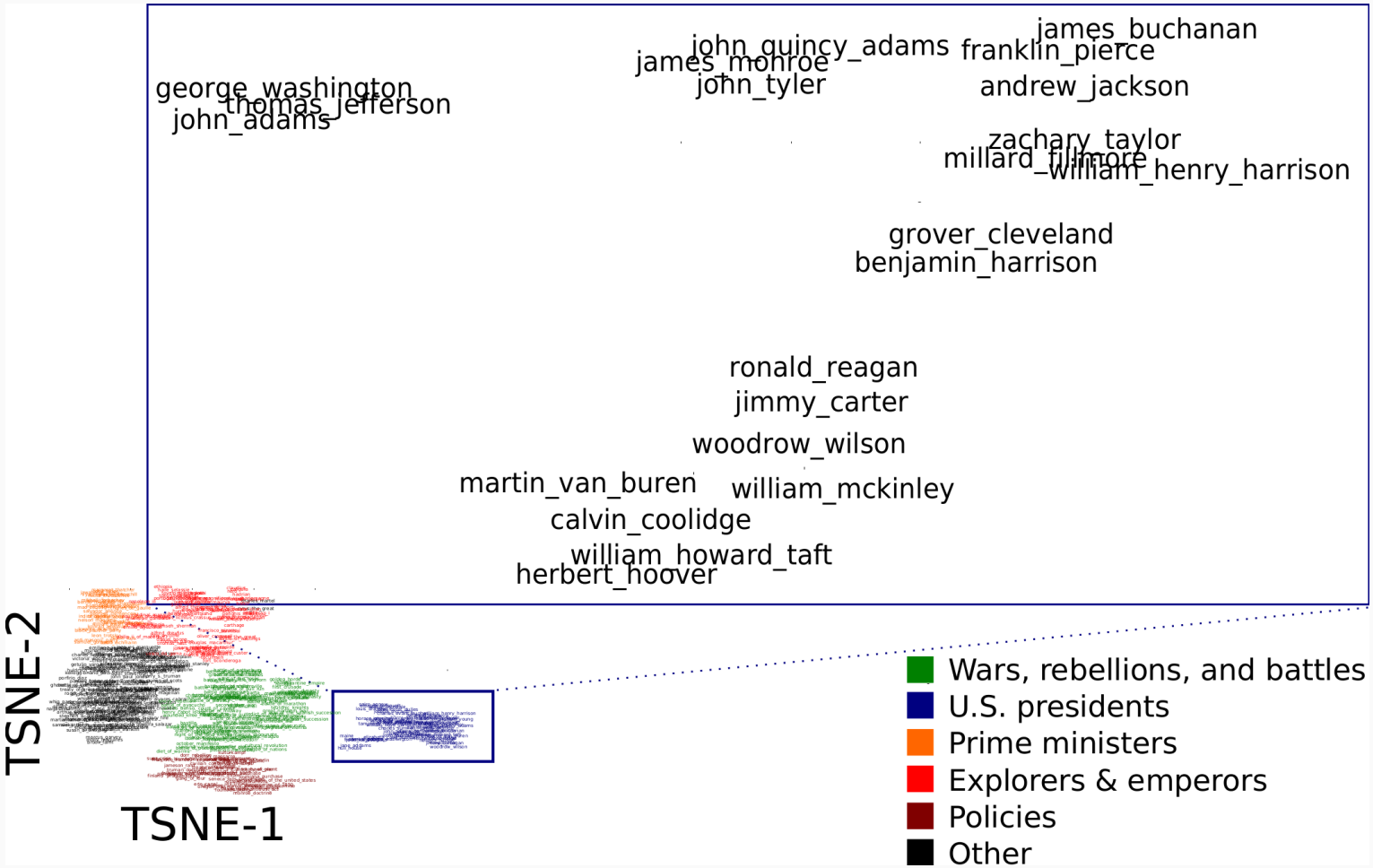
10 random words: *emergency, bluff, buffet, horn, human, like, american, pretend, tongue, green*



10 felines: *cat, lion, tiger, leopard, cougar, cheetah, lynx, bobcat, panther, puma*

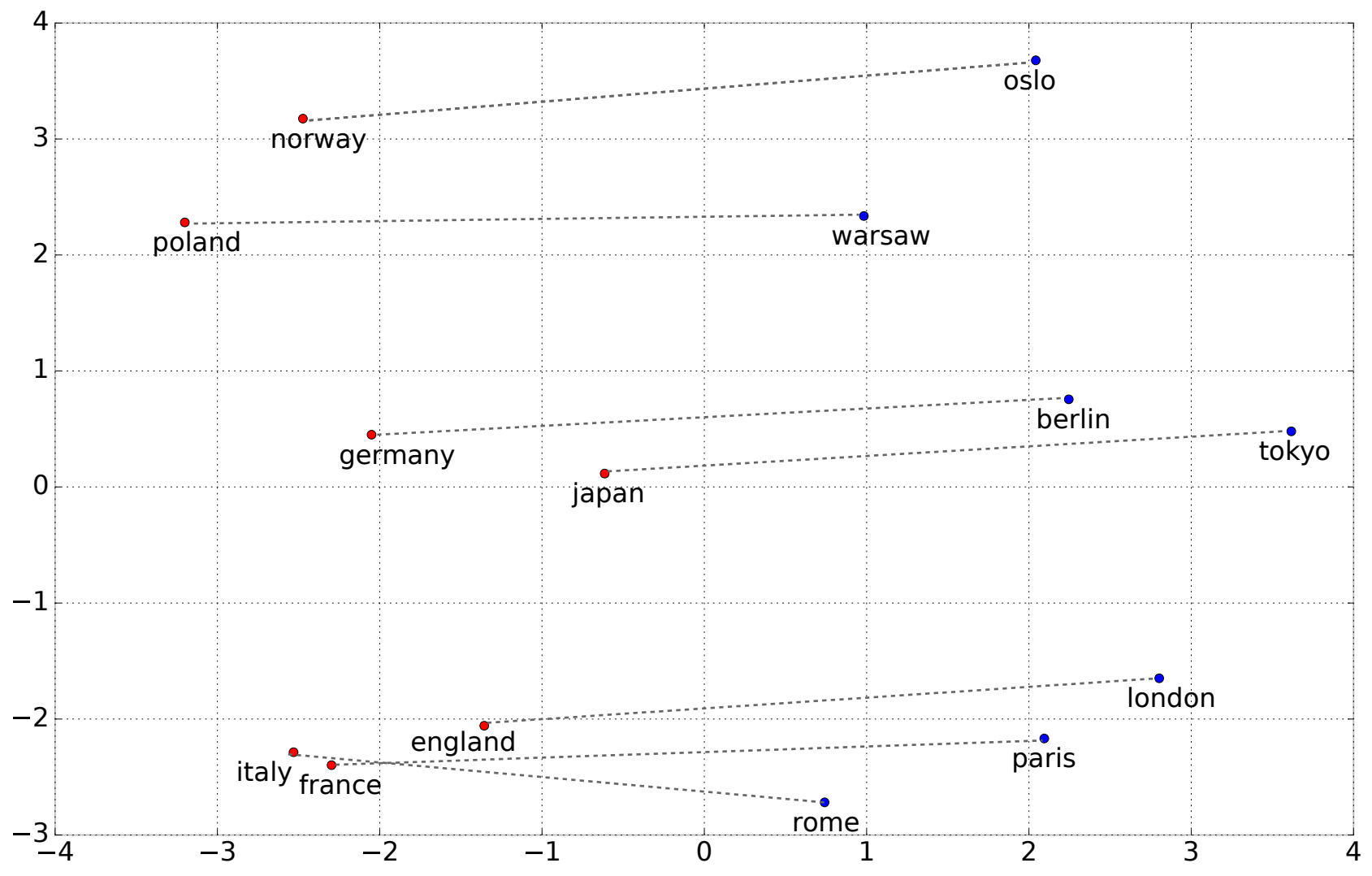
GloVe visualization (Gladkova and Drozd, 2016)

Something meaningful is going on!



Iyyer et al. (2014)

Have we *solved* meaning?



GloVe (Pennington et al., 2014)

Let's extend that!

- subword embeddings (Bojanowski et al., 2017; Cotterell and Schütze, 2015):
- subcharacter embeddings (Sun et al., 2014; Yu et al., 2017; Stratos, 2017; Karpinska et al., 2018):
- syntax-aware embeddings (Levy and Goldberg, 2014a; Li et al., 2017; Lapesa and Evert, 2017):
- retrofitted embeddings (Faruqui et al., 2016; Mrkšić et al., 2016; Yu et al., 2016)
- sentence embeddings (Kiros et al., 2015; Conneau et al., 2017; Bowman et al., 2016; Hill et al., 2016; Le and Mikolov, 2014)

The black box is not entirely magic

- Levy and Goldberg (2014b): Neural word embedding as implicit matrix factorization
- Lebret and Collobert (2015): you're just not using PCA right!
- Overall similar behavior with SVD on analogy task (Gladkova et al., 2016)

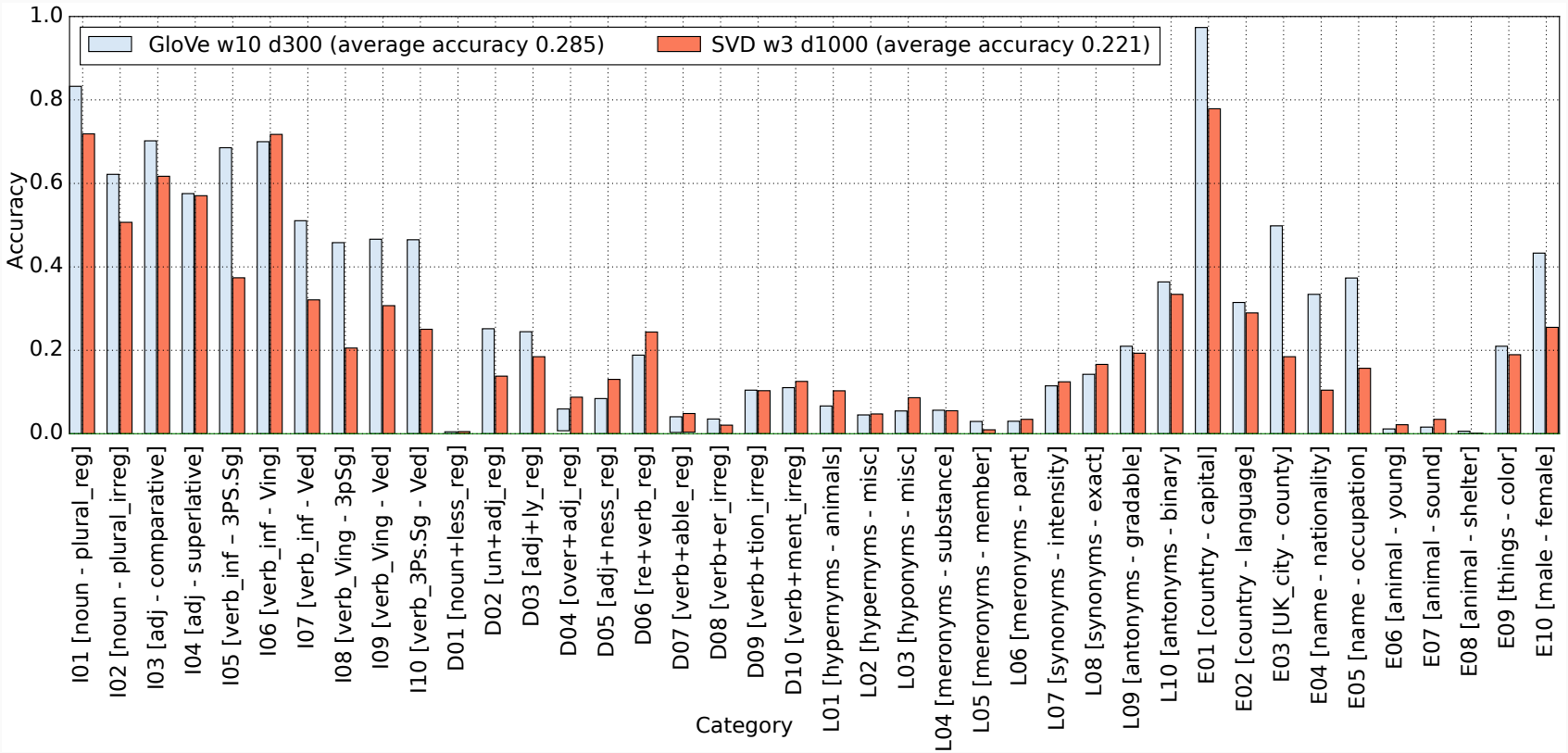
Relatedness/similarity is not a great metric

WordSim353
tiger cat 7.35
book paper 7.46
computer keyboard 7.62
plane car 5.77
train car 6.31
telephone communication 7.50
television radio 6.77
media radio 7.42
drug abuse 6.85
cucumber potato 5.92
bread butter 6.19
doctor nurse 7.00
smart student 4.62
smart stupid 5.81

- task with a long history (Geffet and Dagan, 2004; Turney, 2006; Agirre et al., 2009; Kotlerman et al., 2010)
- WordSim353 (Finkelstein, Garilovich et al. 2002), MEN (Bruni, Tran, and Baroni, 2013), RareWords (Luong, Socher and Manning, 2013), Radinsky Mturk (Radinsky, Agichtein et al., 2011))
- relatedness vs similarity (Hill et al., 2015b; Kiela et al., 2015)
- Methodological problems (Gladkova and Drozd, 2016; Faruqui et al., 2016), x10 for text

No, we don't really have analogical reasoning

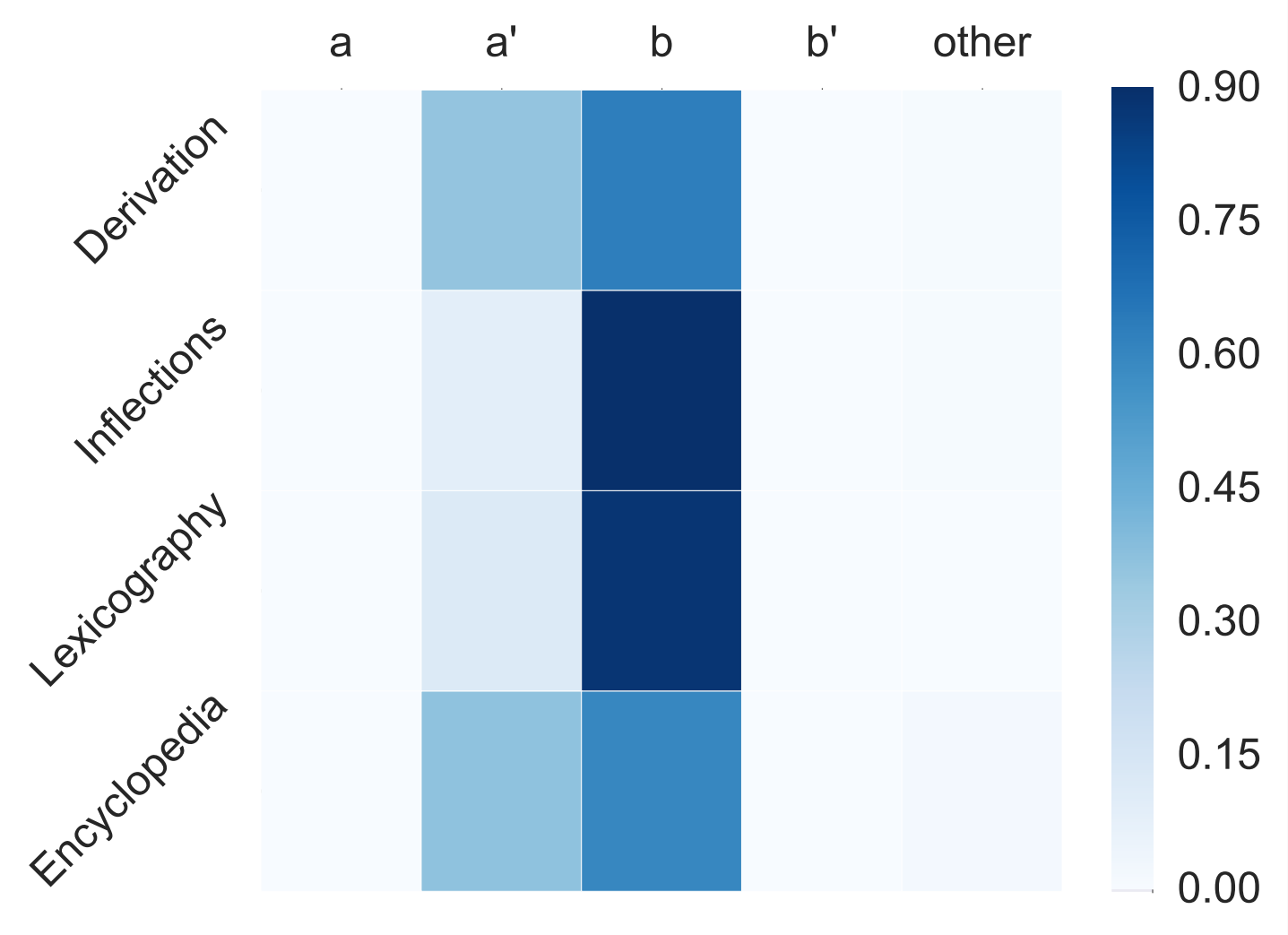
$\overrightarrow{Berlin}$ - $\overrightarrow{Germany}$ + $\overrightarrow{Japan}$ = $\overrightarrow{Tokyo}$ (Mikolov et al. 2013)



Bigger Analogy Test Set (Gladkova et al., 2016)

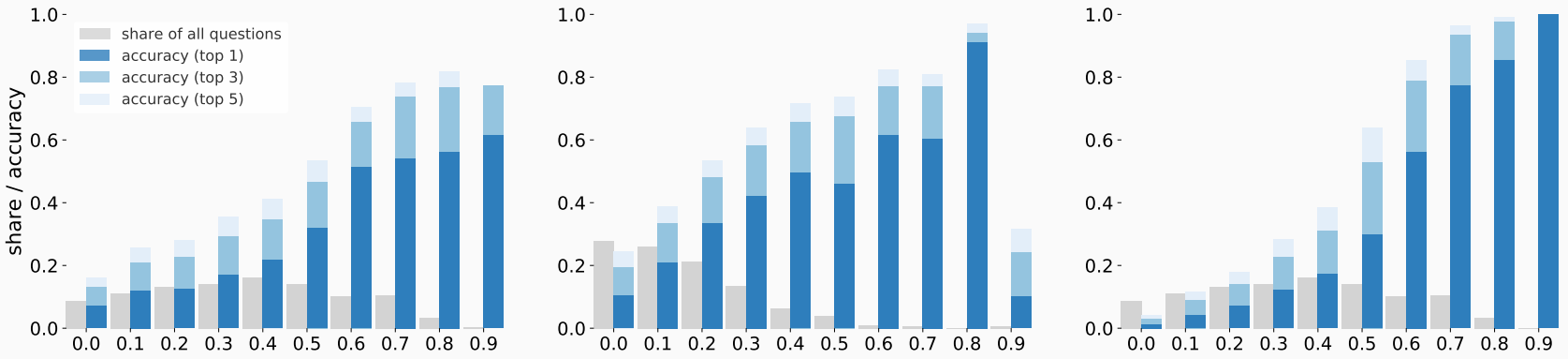
Similar results for Japanese (Karpinska et al., 2018)

Mikolov cheated! (Rogers et al., 2017)



The "honest" solution to $a' - a + b$

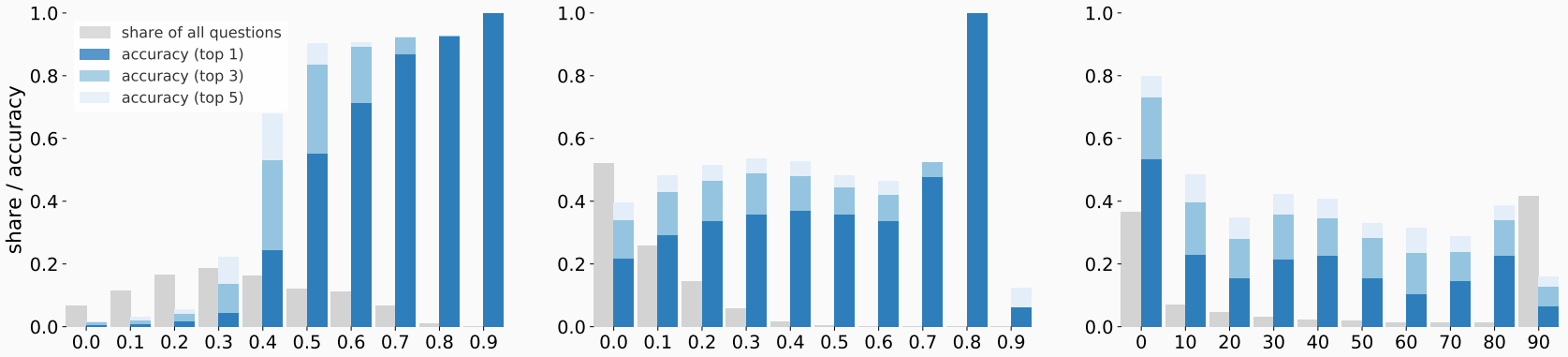
Cosine similarity bias in word analogies (Rogers et al., 2017)



(a) similarity between vectors a and a'

(b) similarity between vectors a' and b'

(c) similarity between vectors b and b'



(d) similarity between vector b' and predicted vector

(e) similarity between vector b' and a

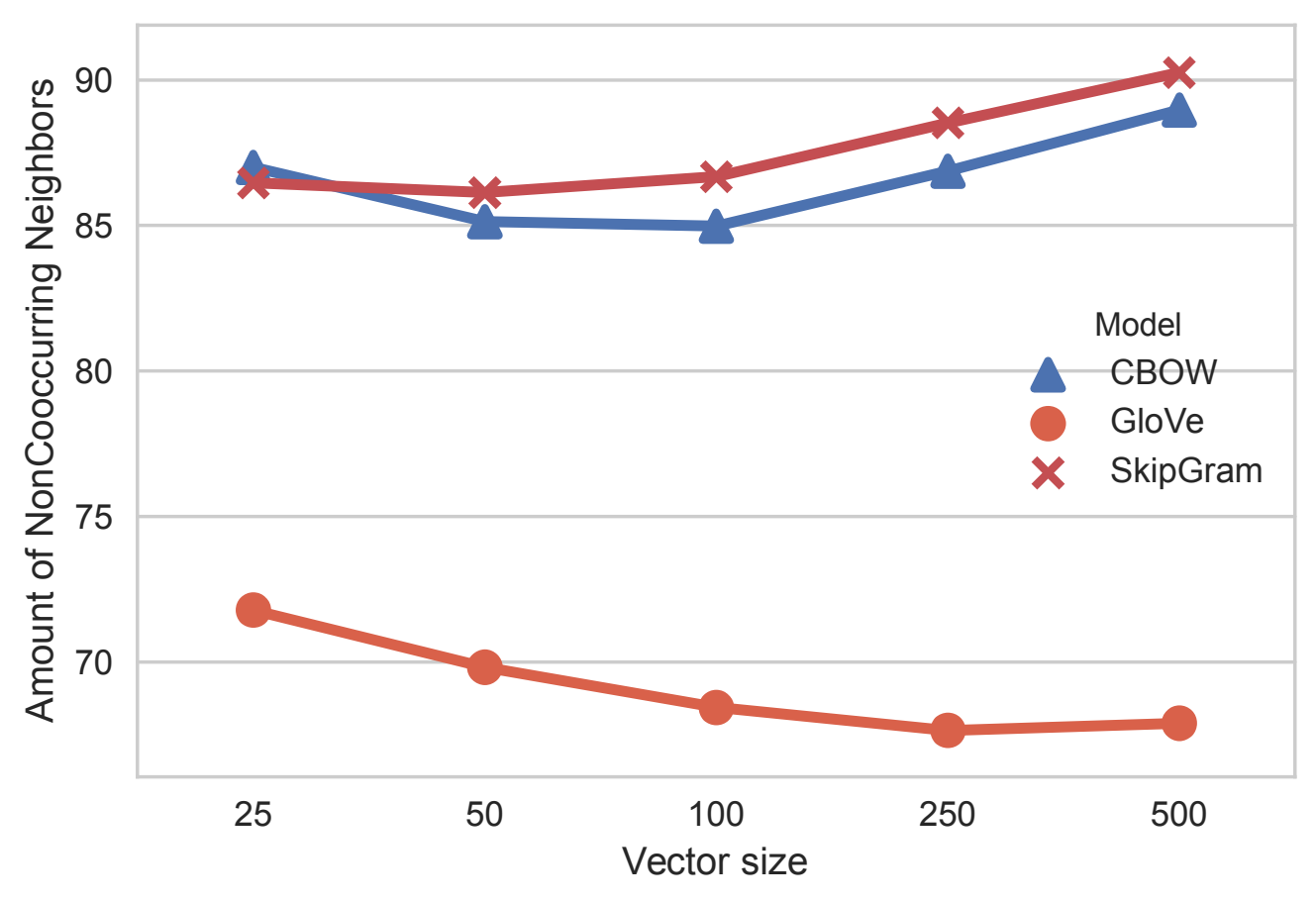
(f) rank of b in the neighborhood of b'

Vector offset method accuracy by cosine similarity bins (GloVe)

Parameters matter a LOT

- Levy et al. (2015): parameters can matter more than the model
- let's study parameters! (Lapesa and Evert, 2014; Lai et al., 2016; Wielfaert et al., 2014; Kiela and Clark, 2014; Melamud et al., 2016b)

Parameters (Rogers et al., 2018)



Detection of word relations without corpus evidence: vector size effect

The shift to extrinsic evaluations

Intrinsic evaluations fail to predict task performance (Chiu et al., 2016; Rogers et al., 2018) $\Rightarrow$

1. “Representative suite of extrinsic tasks" (Nayak et al., 2016)
2. SentEval (Conneau and Kiela, 2018) (partly);
3. GLUE (Wang et al., 2018) and SuperGLUE (Wang et al., 2019);

Quest for high-level reasoning: explosion of QA datasets

- *open-domain QA*: Natural Questions (Kwiatkowski et al., 2019), SearchQA (Dunn et al., 2017), MS MARCO (Nguyen et al.), TriviaQA (Joshi et al., 2017).

- *Extractive RC datasets*: SQuAD (Rajpurkar et al., 2016, 2018), WikiQA (Yang et al., 2015), WikiLinks Rare Entity Prediction (Long et al., 2017), CBT (Hill et al., 2015a), BookTest (Bajgar et al., 2017), MCTest (Richardson et al., 2013), NewsQA (Trischler et al., 2016), CNN/Daily Mail (Hermann et al., 2015), Who Did What (Onishi et al., 2016).

- *Academic QA tests*: RACE (Lai et al., 2017), OpenBookQA (Mihaylov et al., 2018), CLEF QA (Peñas et al., 2014), ARC (Clark et al., 2018);

- *QA involving commonsense knowledge*: MCScript (Ostermann et al., 2018), RocStories (Mostafazadeh et al., 2017), CommonsenseQA (Talmor et al., 2019);

- QA with reasoning over over *long texts* (Kocisky et al., 2018) and *multiple documents*: HotpotQA (Yang et al., 2018), QAngaroo (Welbl et al., 2018), ComplexWebQuestions (Talmor and Berant, 2018);

- Other: QuAC (Choi et al., 2018), CoQA (Reddy et al., 2018), BoolQ (Clark et al., 2019), DROP (Dua et al., 2019) ...

Well, not so high-level, actually

- human-level performance on SQuAD can be achieved while relying only on superficial cues (Jia and Liang, 2017);
- 73% of the NewsQA can be solved by simply identifying the single most relevant sentence (Chen et al., 2016);
- in the commonsense reasoning challenge of SemEval2018-Task 11 (Ostermann et al., 2018) most participants did not use any extra knowledge sources, and one of them still achieved 0.82 accuracy vs 0.84 achieved by the winner;
- models trained on one dataset do not necessarily do well on another, even in the same domain (Yatskar, 2019).

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Ditto for inference

- *NLI datasets*: SNLI (Williams et al., 2017), MultiNLI(Nangia et al., 2017), DialogueNLI (Welleck et al., 2018), MedNLI (Romanov and Shivade, 2018), SciTail (Khot et al.), JHU Ordinal Common-sense Inference (Zhang et al., 2017), SWAG (Zellers et al., 2018) (+ all the RTE datasets)
- *problems with NLI*: Glockner et al. (2018); Gururangan et al. (2018); Poliak et al. (2018); McCoy et al. (2019)

Are we scoring high/low due to representation or method?

Solving BATS word analogies: accuracy for 3 methods
(Drozd et al., 2016)

Method	Encyclopedia		Lexicography		Inflections		Derivation	
	GloVe	SG	GloVe	SG	GloVe	SG	GloVe	SG
3CosAdd	31.5%	26.5%	10.9%	9.1%	59.9%	61.0%	10.2%	11.2%
3CosAvg	**44.8%**	34.6%	13.0%	9.6%	68.8%	69.8	11.2%	15.2%
LRCos	40.6%	**43.6%**	16.8%	**15.4%**	74.6%	87.2%	17.0%	**45.6%**

If we have credit problem with analogies, what about high-level tasks?

Are we scoring high/low due to representation or method?

Solving BATS word analogies: accuracy for 3 methods
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3CosAdd	31.5%	26.5%	10.9%	9.1%	59.9%	61.0%	10.2%	11.2%
3CosAvg	**44.8%**	34.6%	13.0%	9.6%	68.8%	69.8	11.2%	15.2%
LRCos	40.6%	**43.6%**	16.8%	**15.4%**	74.6%	87.2%	17.0%	**45.6%**

a representation with information X readily available

$\Rightarrow$

better performance on task Y

Linguistic diagnostics methodology: what kind of information does your representation prioritize?

1. Choose vocabulary important for your task, or a general representative sample.

in this study: 908 verbs, nouns, adjectives, adverbs, balanced by POS and frequency

2. Get top n neighbors and similarity scores.

Rank	Deps		FastText	
1	colour	0.93	$color	0.75
2	colors	0.72	color...	0.69
3	coloration	0.69	colour	0.69
4	colouration	0.68	color#ff	0.69
5	colours	0.68	color#d	0.68
6	hue	0.66	@color	0.67
7	hues	0.65	barcolor	0.67

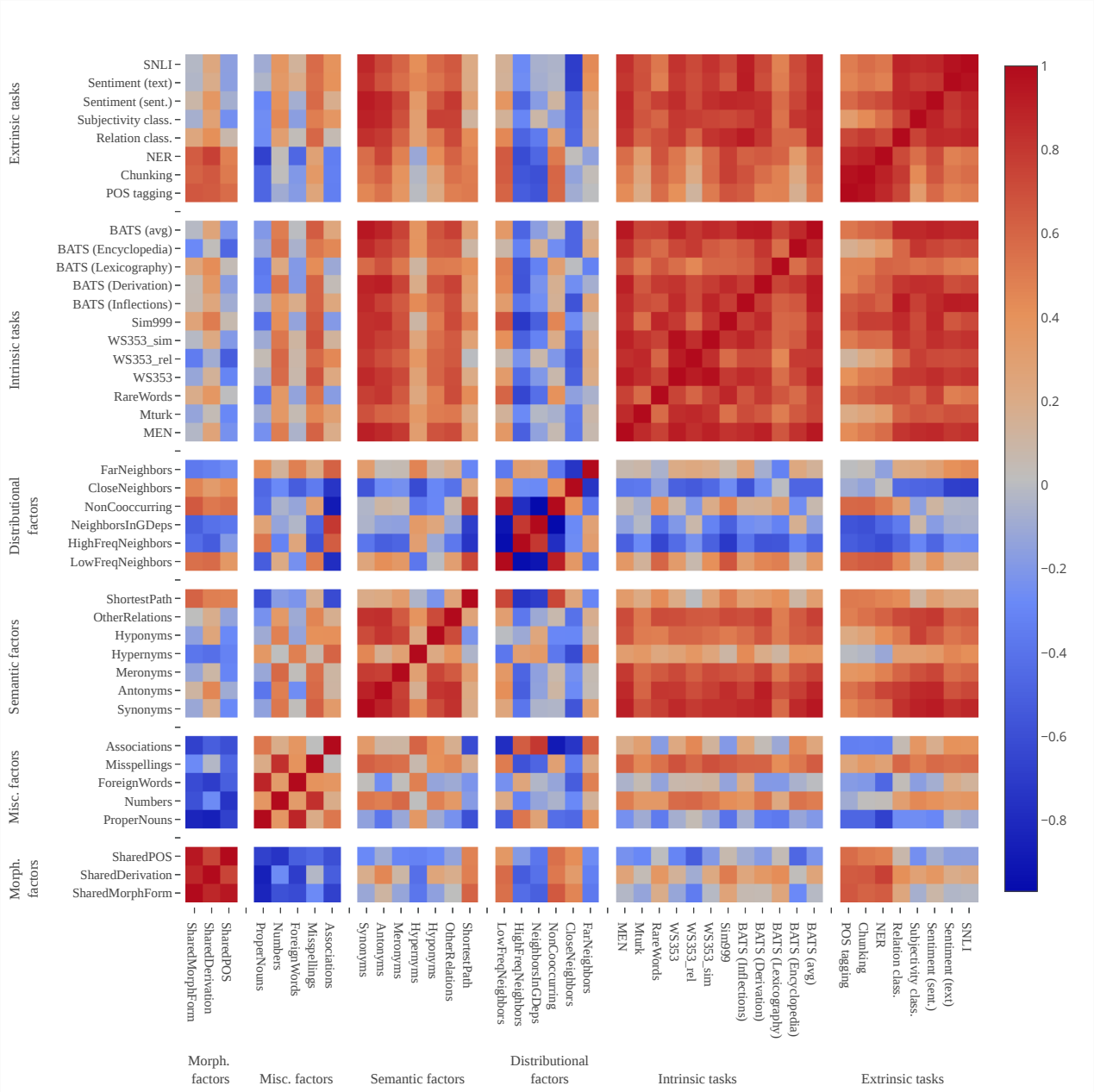
3. Annotate linguistic relations in the vector neighborhoods.

color: colors -> inflected form
color: hue -> synonym
color: coloration -> derived term

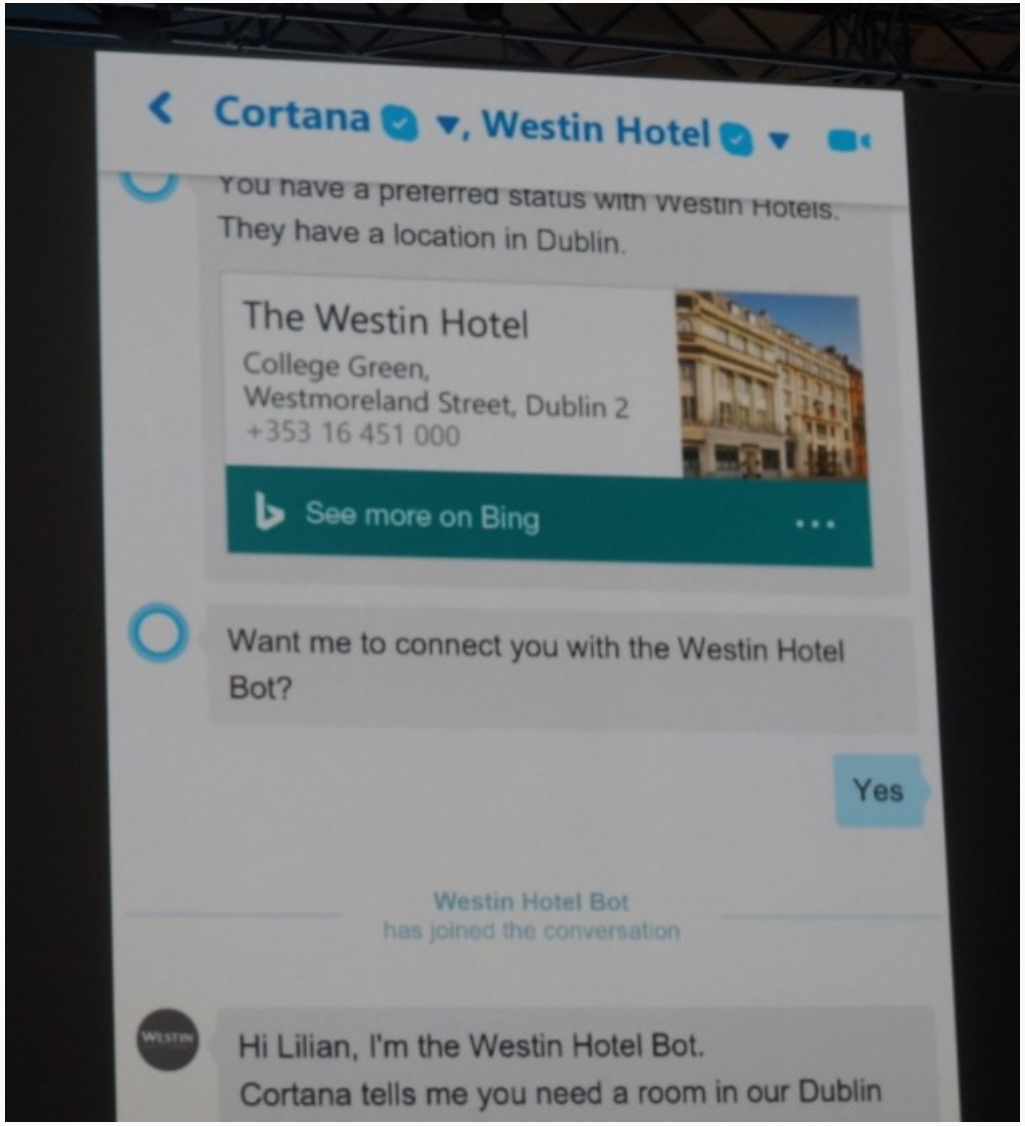
4. Compare models/parameters, adjust, repeat.

FastText: X synonyms, Y antonyms
DEPS: Y synonyms, Z antonyms

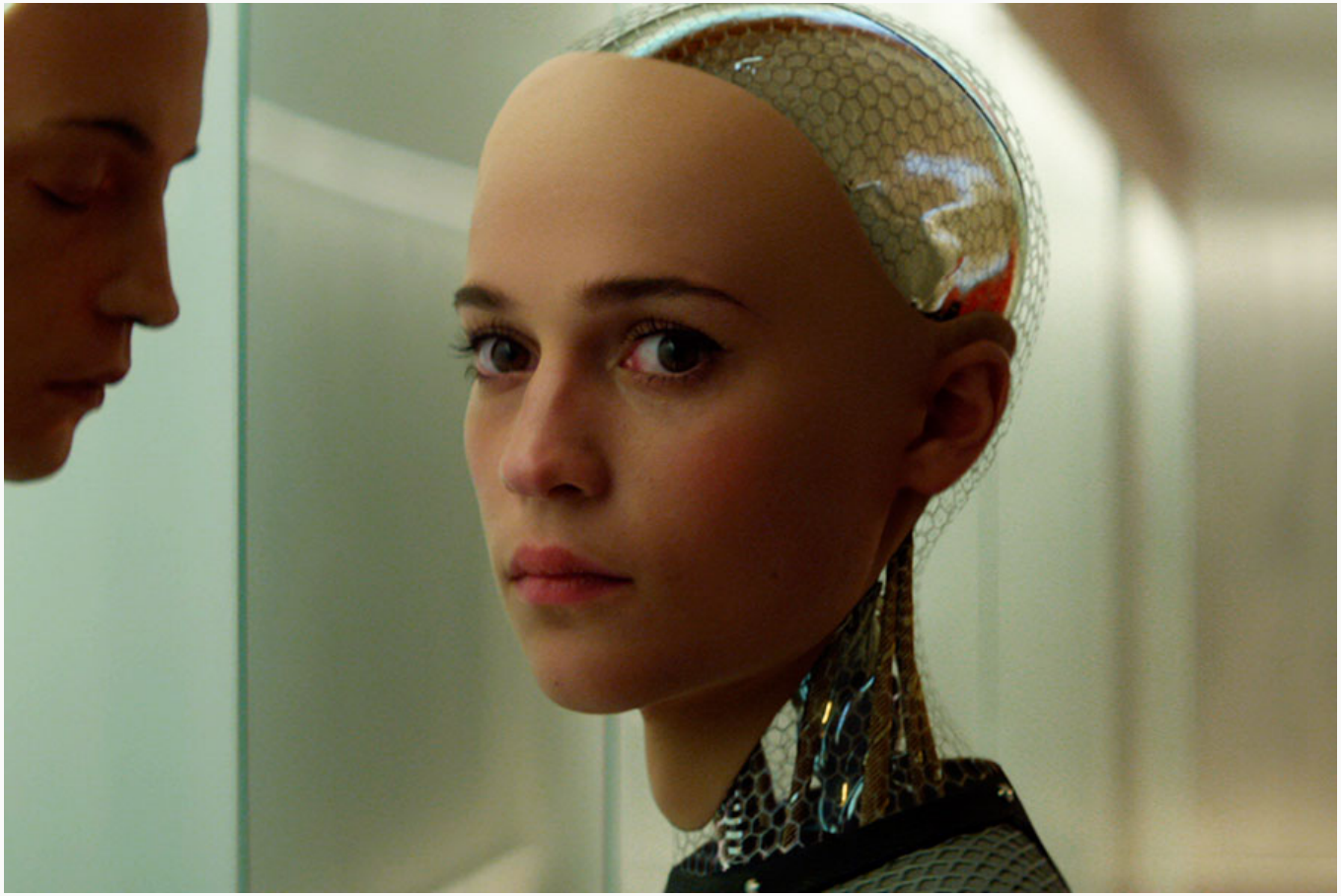
No free lunch: specialized neighbors -> performance (Rogers et al., 2018)



Specialization is great for industrial applications...



... but it won't get us to general AI



Reproducibility crisis

- instability in learned word embeddings (Wendlandt et al., 2018; Antoniak and Mimno, 2018; Pierrejean and Tanguy, 2018);
- variability of results by deep learning methods (Crane, 2018);
- misattribution of impact due to pipeline components;

All of that in a field fighting for +2% gain over SOTA

Push for interpretability

- interpretable dimensions (Nalisnick and Ravi, 2015; Sun et al., 2016; Fyshe et al., 2015)
- linguistically-motivated evaluation of meaning representations (Tsvetkov et al., 2016; Rogers et al., 2018);
- probing for linguistic structures (Ettinger et al., 2016; Liu et al., 2019b; Conneau and Kiela, 2018; Wang et al., 2018; Strubell and McCallum, 2018)
- Workshops: Relevance of Linguistic Structure in Neural NLP (ACL 2018), Workshop on Evaluating Vector Space Representations for NLP (ACL 2016, EMNLP20 17, NAACL 2019), Building Linguistically Generalizable NLP Systems (EMNLP 2017), Workshop on Designing Meaning Representations (ACL 2019), Blackbox NLP (ACL 2019)

Who wants word embeddings anymore?

Rank	Model	EM	F1
	Human Performance *Stanford University* (Rajpurkar & Jia et al. '18)	86.831	89.452
1 Mar 20, 2019	BERT + DAE + AoA (ensemble) *Joint Laboratory of HIT and iFLYTEK Research*	**87.147**	**89.474**
2 Mar 15, 2019	BERT + ConvLSTM + MTL + Verifier (ensemble) *Layer 6 AI*	86.730	89.286
3 Mar 05, 2019	BERT + N-Gram Masking + Synthetic Self-Training (ensemble) *Google AI Language* https://github.com/google-research/bert	86.673	89.147
4 Apr 13, 2019	SemBERT(ensemble) *Shanghai Jiao Tong University*	86.166	88.886
4 May 14, 2019	SG-Net (ensemble) *Anonymous*	86.211	88.848
5 Mar 16, 2019	BERT + DAE + AoA (single model) *Joint Laboratory of HIT and iFLYTEK Research*	85.884	88.621
6 May 14, 2019	SG-Net (single model) *Anonymous*	85.229	87.926
7 Mar 05, 2019	BERT + N-Gram Masking + Synthetic Self-Training (single model) *Google AI Language* https://github.com/google-research/bert	85.150	87.715

Who wants word embeddings anymore?

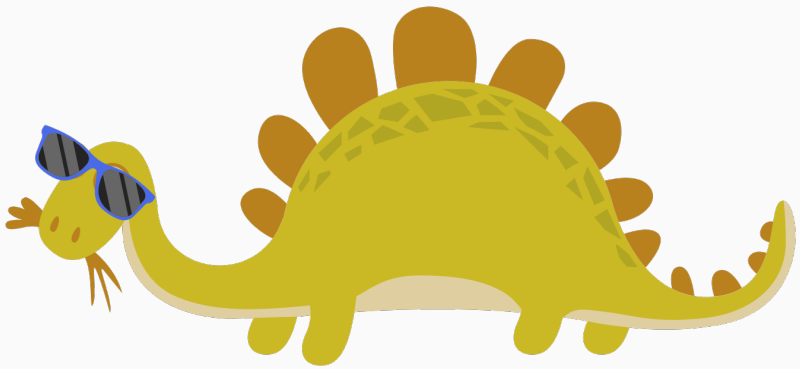
- sense-aware extensions of word2vec (Neelakantan et al., 2014; Liu et al., 2015; Piña and Johansson, 2015; Lee and Chen, 2017)
- early models combining sense and context representaitons (Li and McCallum, 2005; Melamud et al., 2016a)
- TagLM (Peters et al., 2017), CoVe (McCann et al., 2017), ELMO (Bowman et al., 2018), BERT (Devlin et al., 2018), GPT-2 (Radford et al., 2019)

Current problems of contextualized representations

- likely overparametrization (Frankle and Carbin, 2018; Goldberg, 2019; Adhikari et al., 2019; Wu et al., 2019)
- interpretability (Goldberg, 2019; Jawahar et al., 2019; Tran et al., 2018; Liu et al., 2019a)
- too computationally demanding for people in academia to experiment a lot with (and to keep up with the industry)
- scaring away people from other disciplines

Thank You!

Slides: `http://cs.uml.edu/~arogers/` ("Talks" tab)



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